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SCIENTIFIC REPORTS

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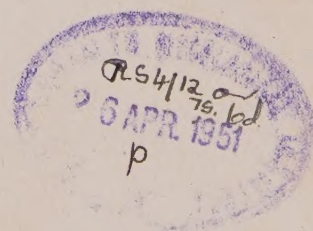
Indian Agricultural Research
Institute, New Delhi

For the year 1947-1948



*Printed by GOSSAIN & Co., Calcutta. On
behalf of the CONTROLLER OF PRINTING &
STATIONARY, GOVT. OF INDIA, NEW DELHI.*

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SCIENTIFIC REPORTS

OF THE

Indian Agricultural Research Institute, New Delhi,
for the year ended 30th June, 1948

REPORT OF THE DIRECTOR

I.—INTRODUCTORY

Further progress was made in the implementation of plans for the organization of the activities of the Institute to enable it to fulfil its functions as a major centre of fundamental research and advanced training in the agricultural sciences. The two new Divisions of Agricultural Economics and Agricultural Statistics have, however, not yet been organized; negotiations have been in progress to obtain outstandingly qualified men as Heads and it is expected that these posts will be filled soon. The development of the Division of Agricultural Engineering has been held up because as pointed out last year no part of the projected workshop has yet been constructed. For this reason it has still not been possible to start the contemplated post graduate course in Agricultural Engineering.

At the request of the Government of India to explore the possibility of manufacturing *gur* and sugar from Palmyra juice an investigation was begun at the Pusa Substation of the Institute and a report on the progress of work so far has been submitted to the Government of India. The work is being continued.

Staff

The position as regards staff improved slightly during the year. Dr. Pradhan returned from his training overseas and was appointed to officiate as Toxicologist. About a dozen Class II posts were also filled up during the year by recruitment of returned Government scholars and others. The Institute is, however, still far from being fully staffed and apart from the two posts of Heads of Divisions mentioned in the first paragraph those for the Divisions of Chemistry, Mycology and Entomology have also not yet been recruited; the last two, however, have been filled on an officiating basis towards the end of the year under report by the appointment of Dr. R. S. Vasudeva and Dr. E. S. Narayanan respectively. A number of Class I and Class II posts still remain vacant as also a large number of subordinate posts. The majority of the latter and some of the former have been filled by recruitment from amongst refugees in accordance with the policy of Government.

Equipment

Mention was made last year of the great difficulties encountered in purchasing scientific equipment and machinery: these difficulties have continued. Moreover difficulties have been experienced in getting stores purchased from foreign countries transported by rail from the port of Bombay.

Land and Buildings

About 104 acres of nazul land to the north-east of the Institute have been transferred to the Institute by the Chief Commissioner, Delhi, for putting up residential and other buildings for the increasing population of the Institute. During the year under report the block of servants' quarters attached to the hostel was completed. Plans for the construction of the school were completed and construction on this item is expected to be taken up soon. Further additions to the laboratories and new buildings for the Divisions of Agricultural Economics and of Statistics and the Engineering Workshop still remain to be taken up as also the Auditorium and the Hospital. As pointed out last year, the slow progress in taking up works which have been sanctioned and for which funds have been provided definitely hinders the carrying out of the research and training programmes of the Institute.

At the Agricultural Sub-station, Karnal, 83.5 acres of land in Block I was occupied by the East Punjab Government for constructing residences for refugees and another area of about 220 acres in the Jodhwala plot was also taken by them for refugee camps. This latter area had been earmarked for production of seeds for the agricultural development scheme for Delhi Province, a work of high urgency and priority. The Ministry of Agriculture have addressed the East Punjab Government to give us land in exchange for what has been taken but the matter has not yet been decided.

Library

The stack room of the Library has now been fitted with an air-conditioning plant to preserve the valuable collection of books. It has not been possible, however, to work the plant or even to test it owing to difficulties in getting electric current for the purpose. Endeavour is, however, being made to overcome the difficulty as early as possible.

The library building was further enriched by a collection of paintings by Mr. E. Brewster, Mr. Bireswar Sen and other artists of note, generously presented by Mr. M. S. Randhawa, Deputy Commissioner, Delhi.

The Library continued to be made use of very extensively. 4,436 books were issued on loan of which 1,004 were sent out to scientific workers in the provinces and in the universities; 7,974 visitors made use of the reading room and consulted 97,228 books during the year.

The library also prepared and furnished during the year thirty bibliographies on various aspects of agricultural science to the scientific workers in the Provinces, universities and the Institute itself.

It acquired from the Torrey Botanical Club, New York, a complete set of printed cards comprising the bibliography of botanical literature from the year 1907 upto 1947.

Irrigation

The old irrigation system consisting of open channels which gave rise to considerable losses of water by seepage and evaporation and which was probably responsible for the steady rise of the subsoil water was replaced by hume pipes. The Central Public Works Department have been approached for the installation of suitable meters so that it may be possible to determine the amount of water actually supplied to particular fields; further this will ensure that payment in future is made on the basis of water actually consumed by the Institute for irrigation.

At Karnal, the sinking of tubewells has at last been taken up and one tubewell is expected to be completed before the next *rabi* season.

Advisory and Survey Work

As in previous years a large number of enquiries from the Government, the Indian Council of Agricultural Research and other bodies, both official and unofficial, were dealt with. The Agronomy Division advised on matters concerning suitable crops, rotations, manurial and cultivation schedules etc., for the particular tracts from which inquiries were addressed. The Ministry of Agriculture was supplied with a note on the damage done by animals and birds to field crops and on control measures. The Botany Division dealt with inquiries regarding identification and exchange of seeds and plants of economic as well as medicinal interest, methods of breeding and cultivation of wild and domestic plants of economic value, hydroponics, preservation of plant specimens in natural colour, and electro-culture. The Directorate of Inspection and Marketing, Ministry of Agriculture was advised regarding the identity and poisonous properties, if any, of the weed seeds found in imported food grains. Advice was tendered to the Indian Council of Agricultural Research on diverse matters such as weedicides of plant hormone type, striga pest of sugarcane, cultivation of *bhabar* grass, multiplication of hybrid *bajra* seed in Madras, cultivation of *Ipecacuanha*, control of wild safflower, and on causes of lack of germination in seed of certain medicinal plants. Advice was also tendered to the Director of Industries and Supplies, New Delhi, on the utilization of sea weeds, to the plant Protection Advisor on wheat varieties resistant to rust and to the Principal, Central College of Agriculture on the syllabus for the first year course. As desired by the Ministry of Agriculture, Government of India, a large number of samples of wheat grains affected by rust during the 1946-47 epidemic were tested in the Division of Botany and Mycology as regards their germination and subsequent short time performance of the seedlings. It was reported that the shrivelled seed could be utilized as seed after making allowances for the germination capacity and reduced grain size in seed rate.

Last year a rapid soil survey was made by the staff of the Chemistry Division of the area proposed to be used for the Central Cattle Breeding Farm at Jubbulpore. During the current year, Major D. T. Brown, Agricultural Engineer, and Dr. R. V. Tamhane, Soil Survey Officer of this Institute, paid a visit and further surveyed the site with a view to framing proposals for the layout of the new farm. Mention was made last year of another survey carried out in the Great and Little Rann areas of Cutch; a final report on the suitability of the soils of these areas for agricultural purposes and the possibilities of reclaiming the land in this area and the mainland of Cutch comprising a total of 9 million acres, and of gypsum and other salts, was prepared and a copy supplied to the Government of India.

In pursuance of the recommendations of the *ad hoc* committee of the Indian Council of Agricultural Research which met on 23rd December, 1947, arrangements were made for the holding of meetings of the two sub-committees in the months of January, February, and April, 1948, with a view to evolve a better procedure to be followed in laying down and conducting the experiments suggested by Dr. A. B. Stewart in his report on soils and manures in this country. Another conference to discuss the irrigation problems of black soils and lines of work of the different irrigation stations in South India with special reference to (a) possibilities of diminishing losses from seepage, evaporation and percolation and of more judicious use of water; (b) damage by salt or water-logging as a result of irrigation and estimates of such damage preventing reclamation and drainage; and (c) design of experiments in irrigation stations, was held in March, 1948 under the chairmanship of the Director.

Mr. G. P. Pillai, Entomologist and Enzymic Biologist, Calcutta, was given at the instance of the Government of India facilities for the demonstration of his method of

ploughless cultivation and production of crops with so-called enzymic manure. For evolving a process for the manufacture of butyl alcohol and acetone Dr. S. V. Desai, Microbiologist (Division of Chemistry), was granted a patent No. 31058 by the Government of India for which the All-India Exhibition (Patents' Designs) held at Calcutta in 1948 has awarded a Certificate of Merit to the Indian Agricultural Research Institute.

The Entomology Division identified specimens of insect pests of various crops and stored grain for various agencies and also supplied them information on their life histories, habits, and control. A large number of samples of seeds were fumigated and the necessary certificates of freedom from infection were issued.

The Mycology Division attended to inquiries concerning identification of pathogenic and taxonomic specimens and also supplied information on their life histories, control measures etc. Suggestions were also offered on the scope of microbiological methods for the estimation of substances of nutritional importance, on methods of assessing losses due to plant diseases and gains effected by control measures. About 350 samples of seeds and plants were examined and treated and the necessary certificates of health were issued.

Reference was made in the last report to a note prepared in connection with a conference convened by the Hon'ble Minister in charge of Food and Agriculture to discuss the situation created by the wheat rust epidemic in Central and Peninsular India. This note was made basis for drawing up a co-ordinated scheme of work on the wheat rusts throughout the country, the scheme drawn up by the Indian Agricultural Research Institute at the request of the Indian Council of Agricultural Research was accepted with small modifications by the Wheat Rust Control Committee set up by the Government of India and it is hoped that work under the scheme will come into being very shortly.

Sale of pedigree dairy stock

During the year 11 bulls and 14 cows of the Sahiwal breed and 11 bulls and 10 cows of the Tharparkar breed, which were surplus to the Institute's own requirements, were sold to Provincial and State Governments or to recognised cattle breeders who are in a position to maintain such cattle, to help them in building up pedigree herds or for grading up their stock.

Visits to the U. K.

The Specialist Conference on tropical and sub-tropical soils organized by the Commonwealth Agricultural Bureaux was held at Rothamsted and Oxford in June, 1948. Dr. J. N. Mukherjee, Director, Indian Agricultural Research Institute and Dr. T. J. Mirchandani, Head of the Division of Agronomy, attended the conference as representatives of Government of India. The object of the Conference was to review the work on tropical and sub-tropical soils; to consider the problems of their classification and nomenclature; to determine the factors responsible for soil fertility; and to consider the design of complex manurial and varietal experiments.

Emphasis was laid on the correct classification of soil so that the data of experiments obtained at one centre may be utilized by workers in another centre.

Since the scientific basis of all practical and economic aspects of utilization of land and the presentation of experimental data centre round the soil type, the Conference emphasised by a resolution the unity of soil studies. It was the definite opinion of the Conference that each country should set up a committee at a high scientific level for the following purposes: (a) To preserve in a central place in each country the soil profiles representative of its soil types; (b) To provide for the interchange of infor-

mation regarding the soil types and data on soils generally, and samples of soils and of profiles, amongst soil workers within the country and also in other countries; and (c) To guide and co-ordinate the scientific study of the soil so as to ensure that soil surveys proceed on right lines. Such a committee would ensure economy of effort and expenditure in obtaining the basic scientific information about the soils of the country. It would also avoid confusion which may arise from the use of diverse methods in the study of soils and of different systems of description of soil profiles and of nomenclature.

Regarding soil fertility it was emphasised that the factors which determine the productivity of the soil were many and there is complex inter-action between them. The Conference came to the conclusion that there was no shortcut method of assessing the contribution of different factors to the productivity of the soil. The study of these factors must be carried out by series of field experiments in which as many factors as possible are tested together and soil conditions defined sufficiently well in the field and in the laboratory to allow similar conditions to be recognized elsewhere. The Conference drew pointed attention to the new statistical designs available for such experiments in order to get maximum information from these experiments.

Other Conferences

The Director and members of the research staff attended the meetings and took part in the discussion of the Indian Science Congress at Patna in January 1948 and of the Crops and Soils Wing of the Board of Agriculture at Madras in April 1948. 11 papers were contributed to the former, and 16 to the latter. The Director presided over the No. 1 Committee of the Board of Agriculture and the Head of the Division of Botany acted as Secretary of the Committee.

Postgraduate Training

34 students completed the two-year postgraduate course during the year and were awarded the Institute Diploma: 9 in Agriculture, 5 in Botany, 3 in Sugarcane Breeding, 7 in Chemistry, 3 in Entomology and 7 in Mycology. 5 students completed the one-year course in plant protection. 49 candidates were admitted to the first-year course out of the total of 95 applications received in all for admission to the postgraduate and plant protection courses beginning from October, 1947.

Facilities were afforded to a number of short course students and honorary research workers as shown in Appendix II. Besides, 4 research fellows were employed during the year, 3 from among the Associates of this Institute and one outsider, to carry out independent research under the supervision of the Heads of Divisions concerned.

The new courses drawn up during the year were as follows:—

Cytogenetics, Crop physiology, Agronomy with special reference to Sugarcane; besides these 2-year courses, a one-year course of training in sugarcane was also instituted.

Hostel accommodation is still constituting a bottle-neck, hindering the admission of a large number of students. Proposals have been made to Government to sanction immediately the ground floor of the proposed 100 room block, which would make it possible to accommodate an additional 50 postgraduate students. It is hoped that this will be done before October when the new students are admitted.

Publications

Fifty seven scientific papers and popular articles on scientific matters were published or were in the press during the year under review. A list of these is given in Appendix III.

Conversazione

A *Conversazione* was held in the last week of March, 1948, to afford an opportunity to the public to acquaint themselves with the work of the Institute. The *Conversazione* was opened by the Hon'ble Minister for Food and Agriculture and was attended by Shri Satyanarain Sinha, Chief Whip, Congress Party and a large number of other Members of the Constituent Assembly, distinguished scientists, and others. This function aroused interest not only amongst those resident in Delhi, but also outside India. For instance, the Egyptian branch of the UNESCO, who had received a set of the brochures describing the work of the Institute, which were issued in connection with the *Conversazione*, wrote a letter of appreciation to the Director and mentioned that they were thinking of setting up similar facilities for postgraduate work in Egypt.

Visitors

As usual, a large number of visitors came to the Institute to see the work in progress. The Hon'ble Minister for Food and Agriculture paid several visits. Besides the members of the Constituent Assembly referred to above, other distinguished visitors included the Maharaja of Bhavnagar; the Maharanis of Jodhpur, Indore and Tripura; the Hon'ble Minister for Works, Mines and Power; His Excellency U Win, the Burmese Ambassador; Members of the Burmese Delegation to the Asian I.L.O. Conference; Members of the Australian Scientific Delegation to the Indian Science Congress of 1948 including Sir John Madsen, F.R.S., Dr. J. A. Prescott, Director, Waite Agricultural Research Institute, Adelaide, South Australia; Members of the Ministries of Agriculture and Education of the Government of India; Directors of Public Instruction of Bombay, Bihar, West Bengal and United Provinces; the Vice-Chancellor of the Annamalai University; Sri Satish Chandra Das Gupta of Sodepur, Calcutta; Dr. J. C. Kumarappa of Wardha; Dr. Mata Prasad, Principal, Royal Institute of Science, Bombay; Dr. H. J. Bhaba, F.R.S., Director, Tata Institute of Fundamental Research, Bombay; Dr. Arthur R. Burns of the Columbia University of New York and Dr. I. P. Trotter, Director of Extension Service, Texas, U.S.A.

II.—RESEARCH AND INVESTIGATIONS

AGRONOMY

Attention was drawn in the last report to the need for recognising that agronomy is not merely the cultural operations and the manurial and varietal trials which are carried out on a Farm but signifies an integrated study of soils, crops and livestock in their climatic setting, of diseases and pests, and all other factors, which are of importance for husbandry. In developing the work of the Division of Agronomy, this fact has been borne in mind.

Staff

This Division has been handicapped in the past by the paucity of technical staff. During the year under report Dr. T. J. Mirchandani and Dr. P. C. Raheja were appointed to Class I posts of Agronomists. The former was later appointed to officiate as Head of the Division, on the retirement from service of Mr. C. H. Parr. An Assistant Agrostologist (Class II) and several Research Assistants and other technical staff were also appointed. With the increase in staff it has been possible to make a proper start with the programme laid down for the Division.

Experiment on Cultivators' Holdings

The results of the principal experiments are briefly referred to below. The experiment on "Cultivators' Holdings" seeks to make an integrated approach to the problems of the industry of agriculture with special reference to the small farmer. The experiment was started on three holdings of approximately 8 acres each and a system of mixed farming is followed. The results obtained during the year again showed that crop yields were generally higher in the two holdings with green manuring than those from the holding without green manuring.

Four new holdings, each of 6 acres, were started during the year under report, incorporating legumes manured with phosphate which would build up soil fertility more quickly than the cultivators' usual rotation system in which phosphate is excluded.

Ley Farming

The first phase of the experiment, *viz.*, the effect of different fertilizers on the yield and quality of a Rhodes grass and lucerne mixture has been in progress since 1945. During the year under report, four cuttings of the fodder were taken; the bulk in the first two cuttings was contributed by Rhodes grass, while lucerne predominated in the two later cuttings. The results of the first two cuttings showed the good effect of P_2O_5 as superphosphate alone or in combination with nitrogen, on the yield of fodder; bone-meal again gave negative results. The analysis of the third and fourth cuttings showed the superiority of superphosphate (applied alone) over the control.

The second phase of the experiment, *i.e.*, the effect of the three years' ley on the soil fertility as judged by the yields of the subsequent crops of maize and wheat, will be taken up next year.

Experiments with nitrogenous manures and fertilizers

In one of the experiments in which the relative value of nitrogen in organic and inorganic manures is being tested, the yields of wheat showed significant differences due to treatments. Farmyard manure gave the best yields, followed by green manuring with cowpeas, leaf compost and castor cake treatments. In another experiment the manurial values of farmyard manure and castor cake were compared with complete fertilizer treatment, keeping the qualities of N, P_2O_5 and K_2O constant in all the treatments. The complete fertilizer treatment gave the maximum yield of wheat, the difference over the organic manure treatments being significant.

Phosphatic manuring of legumes

Reference was made last year to the striking results obtained by phosphate manuring of certain legumes especially *berseem* (Egyptian Clover). A number of experiments continued to be in progress to study the response to phosphatic fertilizers as assessed by the yields of different legumes and those of the subsequent unmanured cereal crops. The two old experiments started in 1940-41 and 1941-42 had their fifth and fourth unmanured crop of wheat respectively, to see the after effects of *berseem* manured with phosphates. During the year under report there was not much difference between the originally phosphate treated plots and the control plots. In the case of the experiment with high doses of phosphate (1940-41 experiment), the after effects had been significant on four crops of wheat grown consecutively; in the other experiment in which low doses of phosphate were applied, three consecutive crops of wheat had given increased yields due to the phosphate treatment of the preceding *berseem* crop.

In the experiment with cowpeas, farmyard manure with phosphate gave increased

yield of fodder and the following crop of wheat also gave an enhanced yield under the same treatment.

In another experiment in which the effect of different forms of phosphates, such as superphosphate, ammonium phosphate, bonemeal and basic slag, is being studied, wheat was grown to study the after-effect of the application of these treatments to berseem. Plots treated with ammonium phosphate gave the highest yield; the combination of phosphate with farmyard manure also gave very good results.

Green-manuring

The experiments conducted during the year under report were mostly directed to the study of the after-effects of green manuring done in 1946-47. In the experiment to assess the relative value of green-manuring when the sunnhemp crop was: (i) grown and buried *in situ*, (ii) grown in another field but buried in the experimental plots, and (iii) grown in another field but buried in the experimental plots after composting, the best yields of the succeeding crops of maize and wheat were obtained from plots treated by the first method. This indicates the value of green-manuring with a legume crop grown *in situ*.

Marked after-effects on the following crops of maize and wheat were obtained in another experiment where indigo was used as the green-manure plant. These results show that under the conditions prevailing here, the residual effects of green-manuring may last for more than one season.

Fertilizer placement experiments

The economic use of fertilizers is a matter of great importance. The experiments on fertilizer placement initiated last year were continued with berseem, the latter sown in rows 6" and 1 foot apart and the fertilizers drilled below the depth at which the seeds were sown being compared with the crop sown and manured broadcast. The former method gave better results than broadcasting but the yield differences were not statistically significant.

Cultural Experiments

A few cultural experiments were started during the year under report. In one experiment the effect of spacing, dates of sowing and depth of sowing on the yield of the gram crop and on the incidence of the wilt disease affecting this crop was studied. The results appear to indicate that late sowing, narrow spacing and shallow sowing, conduce to higher yields. The incidence of wilt was less in late-sown and shallow-sown plots.

The method of ploughless cultivation and "enzymic manuring" advocated by Mr. G. P. Pillai was tested against normal cultivation and manuring, on the wheat crop, and it was found that the latter method was superior to the former.

Flood water farming experiments

These experiments were started in 1941-42 to study the possibility of using surplus river water by flooding fields in July, August and September, for raising crops in areas deficient in rainfall. The results obtained so far indicate that in years when monsoon rainfall has been low, flooding ensures crop growth and yield.

Grasses and Legumes collections : Agrostology

With the starting of the Agrostology Section, the scope of studies and experiments on grasses and legumes has been considerably enlarged. These now include the

testing of grasses and legumes for fodder pasture; for use as rotation crops and as soil builders and improvers. Studies on seed mixtures are also in progress. Ten indigenous grasses and 12 exotic grasses were added to the collection; also 9 indigenous legumes and 4 exotic ones. The grass collection now represents 60 species and the legume collection 16 species.

Cattle Breeding and Management

The Institute has built up and maintains two fine dairy herds, one of the Sahiwal breed at New Delhi, and other of the Tharparkar breed, at the Agricultural Substation, Karnal.

The net and overall averages for the New Delhi herd were 19.5 lb. and 13.7 lb. respectively as against 20.9 lb. and 15.1 lb. recorded in the previous year. The drop in yield was conspicuous from September 1947 and was due to irregularity in the supply of feeding stuffs caused by the disturbances prevailing in Delhi at that time. With the return of normal conditions towards the end of the year, the yield improved considerably.

Statistical Section

The detailed analysis of the dairy records of the pedigree sahiwal herd was continued. Special attention was paid to the data of the experiment designed to study the effect of several feeds on the mineral balance of lactating cows of this breed. The results indicate that manured berseem can maintain a high positive balance of calcium and sodium while the feedings of unmanured berseem created a significant negative balance of phosphorus.

The results of the old and new permanent manurial and rotation experiments at Pusa were reviewed. The former were started in 1908 to study the conditions which determine soil-fertility in a sub-tropical climate, especially the effect of the application of the more important organic and inorganic manures and the inclusion of rotations with legumes and green manures.

The analysis of the data shows that with maize, the response to organic manures was far higher than even with complete minerals, in the case of wheat, barley, peas and *rahar* also, considerable response was obtained from the application of organic manures. Inclusion of a legume as green manure in the rotation has shown beneficial effects which is further augmented by the addition of superphosphate to the green manure.

The detailed results will be found in the report of the Statistical Section.

Agricultural Sub-station, Karnal

The substation is situated about 75 miles north of Delhi on the Delhi-Ambala road. The total area of the substation is 2,154 acres with 1,267 acres under direct cultivation. The irrigation water is drawn from the Western Jumna canal and the supply is hardly sufficient to meet the requirements of the substation. Two tube wells were sanctioned in 1942 and a third in 1945; of these one tube well is now under construction and the two others are expected to be built also in the near future.

The main work at the sub-station comprises agronomic investigations on paddy and other cereals, fodder and forage plants, cattle breeding to explore the possibilities of the Tharparkar breed as a dual-purpose animal, and experiments on mechanical cultivation, mixed farming and on "cultivators' holdings", the latter on the lines already described a little earlier in this report. The detailed results will be found in the body of the report.

BOTANY

Improvement of crop plants through selection of pure types from heterogeneous local material and breeding was the main feature of the work of this Division in the first two to three decades following the organization of this Division in 1905. More fundamental studies of techniques of crop improvement were gradually taken up after the setting up of the agricultural departments in the provinces. It is now recognized that integrated research on related branches such as cytogenetics, physiology, ecology, determination of soil types etc. is capable of dealing more effectively with the problems of crop breeding, especially with reference to resistance to drought, disease, etc. The scientific problems involved in "fitting in" varieties to different climate and soil conditions also require more attention than they have received hitherto in India and it is necessary that the botanist, soil scientist and agronomist work hand in hand in these subjects and not in isolation.

Recent Developments

A qualified cytogeneticist was appointed in 1938 and work in the important field of cytogenetics was initiated; later this unit was developed into a section which has done much useful work. A Section of Crop Physiology was added in 1946 and the work in progress embraces studies on drought resistance and on plant hormones.

Further expansion of this Division envisages organised attention to systematic botany, plant ecology and plant introduction and exploration for dealing with plant and crop surveys and assessing the collections of plant material for utilisation in breeding. A Class I post of Systematic Botanist has been sanctioned but remained vacant owing to difficulty in getting a suitable man.

Equipment

The difficulties in obtaining equipment persisted but in spite of this a microtome, several microscopes, a centrifuge and an incubator were obtained.

Plans were finalised for the construction of a glass house with controlled temperature and illumination and Government sanction is now awaited to commence the installation.

Wheat Breeding

Work on various aspects of wheat improvement has all along been a feature of the Botany Division. Early success was obtained when the strains N.P.4* and N.P.12 were bred; these are still grown over hundreds of thousands of acres to-day. They were followed by a series of wheat outstanding amongst which are N.P.52, N.P.80-5, N.P.101, N.P.111, N.P.114, N.P.120, N.P.125 and N.P.165. In the earlier work, emphasis was laid on yield and quality of grain. In the current work, the question of disease resistance and standing power of the straw is receiving particular attention.

Systematic breeding of rust-resistant varieties for the hills (these being the centres of perennation of the rusts according to Mehta), in collaboration with Dr. K. C. Mehta was started at the Sub-station of the Institute at Simla, under a Scheme financed by the Indian Council of Agricultural Research. Wheat strains combining resistance to the Indian physiologic races of the three rusts respectively have been built up and work is in progress to unite resistance to all the three rusts. Present indications are promising.

* N.P. - New Pusa. Formerly, the strains were designated as "Pusa" or "Imperial Pusa" types.

Facilities for work on the same lines for the plains could not be provided yet. However, in recent years, artificial rust epidemics have been created in the plots at New Delhi and tests conducted for adult resistance. Tests for resistance to the smut disease have also been conducted as a collaborate project of the Divisions of Botany and Mycology.

Wheat Trials

Varietal trials with the more promising partially rust-resistant strains bred recently at the Indian Agricultural Research Institute were continued and the tests were conducted at 17 centres in the wheat-growing areas of the country. Owing to difficulties occasioned by the disturbances in Delhi which delayed the despatch of seeds of the strains, the sowings were late in some places and in some places all the strains could not be included in the trial. In spite of these limitations results of value have been obtained. At almost all places some of the new strains outyielded the best variety grown in the locality previously. The best performance was that of N.P.710 which last year also did very well at a large number of places.

The experiment to study the response of different wheat varieties to different levels of manuring was laid out again, using more suitable varieties. These are N.P.125, N.P.165, Pb.C.518, N.P.710, N.P.761 and a mixture of these five; the manurial treatments are: (a) maximum dose (80N+160P+80K), (b) $\frac{1}{2}$ maximum dose (40N+80P+40K), (c) 40N and (d) no manure. Observations were recorded on plant height, tillering, vigour and yield. In respect of the last-named attribute, the effects of manurial and varietal treatments were significant at levels significance 1% and 5% respectively. Manurial treatment (b) gave the best results followed closely by treatment (a); as regards varieties N.P.761 gave the best yield followed by N.P.165 and Pb.C.518.

Suitable crosses have been made and F_1 grown with a view to breeding wheat strains specially suitable for conditions of intensive farming such as are likely to result from the present efforts to improve agriculture in the country.

Study of the influence of environment on quantitative and qualitative characters

The experiment which was conducted last year to study the effect of environmental factors on the performance of the several wheat varieties was repeated at Delhi, Pusa and Coimbatore using seeds obtained from the previous crop grown at these centres. Observations were recorded on height of plant, tillering, ear-length, grain yield, etc. The results available so far indicate differences between the cultures from seeds obtained from the three places, with regard to some of the above-mentioned characters.

Potato breeding

Potato breeding was taken up in earnest in India in 1935 when a substation of the Institute was set up at Simla, under a scheme financed by the Indian Council of Agricultural Research. A large number of varieties of hybrid origin has been evolved and tested in the hill areas with the cooperation of Provincial Departments of Agriculture. Hybrids 2 and 12 have been found to be particularly suitable in the U. P. hills and Hybrids 5 and 9 in West Bengal. In the plains, testing work has been in progress at Delhi and Pusa and at certain centres in the U. P. and Bihar. The results obtained at Delhi, where most work has been done, indicate that Hybrids Nos. 45, 208, 209 and 2236 are promising.

The Simla Sub-station has been used for the maintenance of valuable collections of wheats and potatoes and also for other experimental purposes and if the Sub-station passes to the proposed Central Potato Research Institute as is anticipated, the Indian

Agricultural Research Institute will be put to considerable difficulty unless a separate substation with buildings and equipment is provided for this Institute.

Hybrid vigour

Maize is a crop which has been much neglected in the past, in this country. Experiments on hybrid vigour, inbreeding and improvement of methods of hybrid seed production were continued under a scheme financed by the Indian Council of Agricultural Research. Commercial varieties, both Indian and foreign, single and double crosses imported from outside were under study to evaluate their utility for commercial purposes. Four double crosses imported from Australia were found to be particularly promising and arrangements are being made to test them in the important maize-growing tracts.

Other breeding and genetical investigations

Breeding for wilt-resistance in pigeon-peas, for rust-resistance in linseed, for high nicotine in tobacco, and for heat tolerance combined with high vitamin C content in tomatoes, was continued.

Genetical investigations on the inheritance of sex-forms in *Luffa* were completed and a note published in "Nature". The experiment on the artificial production of chimeras has been suspended for the present.

Cytogenetics

The important lines of investigations in progress include the study and utilization of different techniques of plant breeding like polyploidy, interspecific hybridization and mutations for crop improvement.

The colchicine—induced autopolyploids of a number of crop plants were under study, as in the previous years, with a view to evolving superior tetraploid strains. The tetraploid selections of Chilli (*Capsicum annum*), gram (*Cicer arietinum*) and *til* (*Sesamum orientale*) were again under observation but no appreciable improvement in fertility was noticed in them. However, a few selections in chillies grown at Pusa appeared promising on the basis of fruit yield. Progenies both from highly fertile single plants and inter-varietal crosses in *Brassica* species were grown and studied with special reference to morphological characters, habit, maturity and seed fertility. Observations on seed fertility in the tetraploid *toria* (*B. campestris* var. *toria*) revealed that as a result of selection year after year, there has been an increase in the frequency of plants with high fertility. Further crosses were made among the suitable plants to bring about combinations of several desirable characters.

Progress was made in the breeding of strains of *til* (*Sesamum orientale*) resistant to a virus and to a caterpillar pest. The progeny of the back-cross (*S. indicatum* × *S. orientale*) was under study for cytological behaviour, pollen fertility, important morphological characters and disease incidence. Although the majority of the plants resembled *S. orientale* both in chromosome number and morphological characters, there was evidence of the transference of some characters of the wild parent.

Crop physiology

The non-irrigated area under wheat in India is far greater than the irrigated, and the yield level under the former conditions is on the whole lower. Investigations have therefore been in progress to study the physiological principles that are likely to be of interest in breeding wheat for drought resistance.

A comparative study of ten varieties of wheat grown in pots, was taken up to test their drought resistance. The plants were subjected to intermittent soil drought by withholding water until the leaves just wilted. Varieties N.P.52, N.P.710 and CPH47, which gave comparatively low yields with normal moisture, suffered less under drought and also yielded more. These varieties may thus be regarded as relatively drought resistant as well as more useful from the practical point of view of yield.

A comparative study of the assimilatory capacity of the ear of 5 varieties of wheat indicated appreciable difference in the contribution that the assimilation of the ear makes to grain-filling. In N.P.710, the contribution by the ear amounted to 43%, while in N.P.165, Agra Local and Punjab 9D it was about half as much. What bearing these differences have on the performance of varieties under different environments appears worth consideration. It is tentatively suggested that the comparatively greater drought resistance of N.P.710 may be due to the high assimilatory activity of its ear, since the translocatory mechanism would be less active due to water-strain.

Seeds of N.P.4 wheat, pre-treated with water and dilute salt solution did not give any increased yield, possibly because the good winter rainfall offset the effect of pre-treatment which is more suited to 'barani' conditions.

Observations on the growth and yield of the permanent wheat plot were taken according to schedule. In a preliminary experiment to see the effect of fluorescein on wheat it was observed that its application at the rate of about 1.5 p.p.m. of soil increased grain yield mainly by increasing the number of ear-bearing tillers.

Plant introduction and exploration

A scheme for starting work on a small scale for plant introduction and plant exploration, financed by the Indian Council of Agricultural Research, came into operation in 1946. During the year some of the areas in Orissa were surveyed for the purpose of the collection of seeds of important indigenous wild plant material and a number of species of legumes, and malvaceous and solanaceous plants were collected.

Nearly 200 samples of a number of plants, mostly of grasses and legumes, and of new improved varieties of various crop plant and other plant breeding material, were obtained from various countries. The new imported varieties include rust resistant wheats, barleys with high malting quality, legumes such as soyabeans, peas, mung, beans, etc., cruciferous vegetables such as radish, turnip, cabbage, etc., varieties of safflower and linseed, etc.

A fairly large number of exotic and indigenous wild and cultivated plants was under observation.

Seeds of some of the new plants were supplied to Provincial Agricultural Departments and Institutions for trials.

Seed Distribution

As in previous years the demand for improved seeds exceeded the supply. There was a heavy demand for some of the N.P. wheats particularly of N.P.52 of which some of the indentors offered to purchase all the seed that could be supplied. Only a small part of this demand could however be met. The seeds of the improved N.P. strains were distributed chiefly to the Provincial and State Departments of Agriculture.

SUGARCANE RESEARCH

Plant Collections

The success achieved in the breeding of economic type in the sugarcane is due mainly to the available initial materials especially of the related wild species, *Saccharum spontaneum*. Though there has been no organised expedition so far for making systematic collection from the various parts of India and elsewhere, sufficient materials had accumulated during the course of many years of breeding work since 1914. These include many varieties of (a) *Saccharum officinarum*, (b) *Saccharum Barbari* and *Saccharum sinense* (North India Canes); (c) *Saccharum spontaneum* and (d) a few types of the related genera like *Narenga*, *Sclerostachya*, wild *Sorghum* and *Brianthus*. Among these, *Saccharum spontaneum* has the widest range of distribution extending from the slopes of the Himalayas to the tropics of Sumatra and Java. From the study of the miscellaneous small collections of this species which has been made, it is found that it is distinguished by having many eco-types with distinct chromosomal variations. So far only two tropical types of *Saccharum spontaneum* had been used both at Coimbatore and in Java for breeding. An expedition for the exhaustive collection and the study of the different forms of *Saccharum spontaneum* and related plants from the various parts of India is being organised and is financed by the Indian Central Sugarcane Committee. This is expected to widen the scope of sugarcane breeding work by enabling the introduction of hardy qualities as resistance to frost, drought and disease in the future commercial canes. With the appointment of an Assistant Botanist a start has been made this year to collect *Saccharum spontaneum* and related grasses growing wild in the different ecological situations in the Madras Presidency.

The already existing collections of cane varieties and related plants are now maintained under tropical conditions at Coimbatore and sub-tropical conditions at Karnal. The maintenance of the Live Herbarium at Karnal is especially important to study the responses of the parent materials to the conditions obtaining in the sub-tropical belt.

Breeding technique

Sugarcane breeding is now systematised, starting from mass hybridisation and ending with the distribution of Coimbatore canes to the Provincial Sugarcane stations. However, further improvements in the technique during the various stages are found to be necessary for introducing greater precision on a scientific basis. Country made earthenware sowing pans are now being replaced by uniform glazed pans with distinctly better and even germination of seeds. Selection of seedlings is not restricted to particular portions of plots as before and is now made to cover whole plots in the first ground nursery. Randomised replications have been introduced consistent with the limited area now available, in the various stages of selection before the release of the seedlings to the various provinces.

Improved cane varieties

Under the essential limitation that the breeding work has to be restricted at Coimbatore because of the favourable conditions for hybridization work, it was felt that the policy of sending only a few seedlings of outstanding performance at Coimbatore to provinces had to be modified because of the different climatic and environmental conditions prevailing in North India which constitutes the largest area under cane. During the year cane varieties in all 30 with good qualities regarding habit, Sucrose content etc., but with a wider range of performance were distributed to the various provincial

stations giving them a good choice for the selection of suitable varieties adapted to particular environmental conditions.

The recent experiences in breeding work have indicated that varieties respond differently under different levels of soil fertility and this factor is of considerable importance in commercial crops like sugarcane where manuring is an extensive agricultural practice to advance the yield especially in the areas with facilities for irrigation. To make breeding work in sugarcane more comprehensive preliminary experiments have been initiated for the selection of suitable varieties under low, medium and high fertility levels.

The recognition of suitable parents for transmitting useful characters in the progeny is important for sugarcane breeding, especially in view of the complicated genetic make-up of the cane materials which are either complex polyploids or hybrids. Experimental crossing, however, greatly facilitates the selection of parents which are later used for mass hybridization for the selection of suitable cane seedlings with the desired characters. The choice of the parents is based on important qualities as tonnage, maturity, quality of juice, stand etc., transmitted to the progeny. The finding of such parents is an important feature of the sugarcane breeding programme. In this connection it may be mentioned that no serious attention has been paid so far at Coimbatore regarding breeding for disease resistance. This problem is sure to gain importance very soon as the Coimbatore varieties are in extensive and intensive cultivation under different environmental conditions. The selection of resistant parents to different important diseases such as red-rot and to insect borers under artificial conditions of infection should in future form an important part of the sugarcane breeding programme.

Cytogenetical studies

The study of the behaviour of chromosomes in interspecific and intergeneric hybrids has provided explanations for certain distinguishing features of sugarcane as compared to other crops, especially in the breeding aspects. Such studies on the fundamental scientific issues are expected to lead to the understanding of the processes by which the indigenous canes of India (northern Indian canes) have originated in nature. These canes (*S. Barberi* and *S. sinense*) are considered to be polyploid complex hybrids between the noble canes *S. officinarum* and *S. spontaneum*. Studies are now in progress to trace the origin of *S. officinarum*. Work done so far has indicated that this species is a composite of two fundamental species each with a basic chromosome number $x=5$ and one of these is present also in a related grass belonging to the different genus, *Sclerostachya*. These studies have a practical bearing on the synthesis of better economic forms from fundamental species when these are identified. Certain crosses have been made this year with a view to ascertain the homology of the second basic complement of $x=5$ of *S. officinarum*.

Physiological studies

Investigations of the conditions governing the flowering of the sugarcane are in progress with the object of bringing into breeding certain non-flowering canes as well as to delay or hasten flowering to suit the hybridisation programme. By manipulating factors like photoperiod, manuring and irrigation, it has been found possible to induce flowering in a number of useful non-flowering varieties and adjust the time of flowering in a number of late and early flowering varieties. Study of chemical composition of cane varieties in relation to flowering habit which is in progress has not indicated any marked differences between the flowering and the non-flowering varieties except in the soluble carbo-hydrate content and total C : N ratio.

CHEMISTRY

The Division has been reorganised into the following sections:—

1. General Agricultural Chemistry.
2. Soil Chemistry.
3. Soil Fertility.
4. Micronutrient Elements.
5. Soil Physics.
6. Physical Chemistry.
7. Soil Survey & Land Utilisation.
8. Organic Chemistry, including Plant Chemistry.
9. Soil Microbiology, and
10. Biochemistry.

Equipment

During the year under report a substantial part of the equipment for Soil Survey and Cartography was obtained. A Hellige-Troug combination soil tester has been added; this will facilitate quick examination of a larger number of soil samples in the field. An ultra-violet lamp, a viscosity apparatus and a colorimeter were also obtained.

Manurial experiments (Delhi)

Investigations have been in progress in collaboration with the Agronomy Division on the effect of phosphatic fertilizers applied to legumes and application of heavy doses of complete fertilizers to cereals, on the building up of soil fertility. Analysis of the first year *rabi* and *kharif* crops indicates that the nitrogen and phosphorus content of the grain from the treated plots is more than the control.

Manurial experiments at Pusa (Bihar)

The permanent manurial plots at Pusa received greater attention and investigations on these were continued. Arrangements for the establishment of a small chemical laboratory at Pusa are in progress. When it is completed it will be possible to do some detailed work on these plots.

Soil Chemistry

The soils from each of the experimental plots at the Indian Agricultural Research Institute under soil fertility maintenance and building up experiments were collected before the commencement of the experiments and analysed to ascertain the plant nutrient status. The analysis of plant material and soils from the permanent manurial plots at Pusa was continued.

Soil Fertility

Indicator plant studies.—The purpose of the investigations is to select suitable plants to indicate the deficiencies of major plant nutrients (P_2O_5 , N, and K_2O) in the soil either by visual deficiency symptoms or by the response in the yield to the suitable selected fertilizers. The field experiments to study crop response were laid out according to Wallace who recommends the layout to be done in two blocks—one to be unlimed and the other limed, with various combinations of P_2O_5 , K_2O , Mn, B, Mg and N, N to be in the form of ammonium sulphate. The deficiency symptoms exhibited by crops like potato, oats, rape, sunflower, lettuce and grain were followed by recording

visual symptoms and by rapid tissue tests. The yield data are being studied to judge the effect of any deficiency on the yield of crops.

Lysimeter studies have been conducted from 1945 with a view to study the effect of fertilizers on crop yield, crop composition, and the residual effect of fertilizers on succeeding crops. The results of this year point out that NP treated wheat gave more than double the yield, while N treatment gave 55% increased yield and P treatment 6% less yield than the no manure (control). In the legume rotation, the yield of wheat following cowpea after P treated wheat was better than that of wheat following cowpea after untreated berseem. The former gave nearly three times more yield and the latter gave about two times more yield than the unmanured wheat in the cereal rotation.

Foliar diagnosis studies.—This year's analysis of leaf samples of barley from the old permanent manurial plots, Pusa, series A, showed that high yields are associated with a mean intensity value between 11 and 12 and optimum range for mean composition of $N-P_2O_5-K_2O$ between 25-34. These are also indications that low yields are possibly associated with non-mobilization of nutrients from the leaf to the plant.

Micronutrient studies

Investigations on the diseases of gram were continued. Plants showing symptoms of "bronzing", "yellowing-bronzing", and "top yellowing" contain less boron; plants with "bronzing" and "yellowing-bronzing" contain low phosphorus and in "top-yellowing" plants manganese content is low. Soil nearer the root zone of diseased gram plants is found to contain more nitrite and nitrate. Pot experiments to study the effect of trace elements on the nitrogen assimilation of gram showed that uptake of organic nitrogen, height and yield of the plants were greatly influenced by manganese and molybdenum. The effect of boron was not appreciable. Gram diseases are also under investigation in the Division of Mycology.

Under a scheme financed by the Indian Council of Agricultural Research, the role played by micronutrient elements in the deficiency diseases of citrus is under investigation.

Soil physics

Investigations on percolation, permeability and pore space of soils were continued

Physical Chemistry

The absorption spectra of sunnhemp virus and cowpea mosaic virus, along with their fine structures were studied. These preliminary results showed that the two viruses are not identical.

Soil Survey & Land Utilisation

Jubbulpore.—Following the rapid reconnaissance survey conducted last year, a detailed examination of the soils in an area of 3,000 acres, intended for the establishment of a Central Cattle Breeding Farm has been undertaken. The soils show the following variations, (1) black soil to a depth of more than 6 ft. without any marked change in the horizon, (2) black soil changing at about 4 ft. depth into a reddish brown soil, and (3) a uniform greyish black soil profile. All the soils are clayey, with a clay content between 44-50 per cent.; and, in general, contain low amounts of plant nutrients. The soils show differences in calcium carbonate content and pH.

Rann of Cutch.—The Rann of Cutch is estimated to contain over 8,000 sq. miles of which 6,700 sq. miles is in the Indian Union. In a very rapid reconnaissance survey, about 150 sq. miles were covered and the soil profiles collected have been further examined in the laboratory. The soils contain large amounts of salts, predominantly

sodium chloride. The presence of gypsum in the profiles is a special feature. The soils are mildly alkaline. Opinion was expressed that at least some limited areas could be reclaimed and the recovery of gypsum and salts will reduce cost of reclamation. The need for further detailed work was stressed. Full reports have been sent to the B., B. & C. I. Railway authorities, to the Ministry of Agriculture and the Ministry of Works, Mines and Power.

The survey of the Institute Farm and the Karnal Substation which was commenced last year was continued and the soil samples collected were analysed. Some variation is noticeable as regards the morphological features of the profiles and the presence or absence of lime and iron concretions. The occurrence of saline and alkaline patches at the Indian Agricultural Research Institute appears to be associated with a general rise of the subsoil water table.

The topographical survey of the Institute Farm area and the Karnal Substation area have been completed.

Soil Microbiology

Nitrifiability of different kinds of manures and fertilizers in some of typical soils of India under varying conditions of moisture and temperature is under study. Peas were found to utilise phosphoric acid from bonemeal or rock phosphate and fix nitrogen.

Under the "Nitrogen Fixation Scheme" financed by the Indian Council of Agricultural Research, work on the isolation of the strains of gram and rahar root nodule bacteria from different localities and testing their efficiency has been taken up. In red soils of Coimbatore nodules were not present on gram plants but plants from black soils showed nodules.

Palm Gur

Investigations on the manufacture of *gur* and sugar from palmyra palm were undertaken.

The work on this scheme was conducted at the Botanical Substation of the Indian Agricultural Research Institute at Pusa, Bihar, during the winter of 1947 and the summer of 1948. The main problem was how to collect the juice in a pure, unfermented condition. It was found out that there were two places where infection generally took place, the one at the source of juice which comes out of the spathes and the other is the collecting pots. The former was successfully checked by application of an emulsion of lime, coconut oil and formalin. To stop the fermentation in the collecting pots various antiseptics were tried and formalin was found to be the best of these. At a suitable concentration, the juice could be kept unfermented for about 96 hours. The *gur* prepared out of this juice was of golden colour. Formalin can replace lime with advantage as a juice preservative. The *gur* prepared using lime as a preservative gives a slightly darker colour as it is extremely difficult to remove all the traces of lime whereas in the case of formalin the *gur* is generally of golden colour.

Samples analysed

In the course of the year 450 samples of soils, manures, fertilizers, feeding stuffs, etc., were analysed and advice given. About one thousand samples of soils and plants were analysed in the research programme.

ENTOMOLOGY

National Insect collection and taxonomic studies

During the past four decades, a large and valuable collection of over 25,000 named species has been built up by the Division. During the year the following specimens were received from abroad and added to the collection: 86 specimens of Aphidæ from Nirostar Kocurak of Hranice, 47 species of Coccinellidæ, 3 of Mardellidæ, 15 of Anobiidæ and 2 of Aphidæ from Ing. Viktor Gunther, Praha (Czechoslovakia). 90 specimens of *Sitophilus oryzae* were donated to the Professor of Entomology, California University.

Taxonomic studies on parasitic Hymenoptera, Isoptera and Acrididæ were continued.

Population studies

Population studies of insects are important as affording an idea of the biological balance and the climatic factors affecting it. Data from carefully planned experiments would enable epidemics of injurious insects to be forecast, so that control measures can be adopted in time. A scheme for research on insect populations, with special reference to the spotted bollworms of cotton, has, however, been in progress at the Institute since the last five years or so, but it has not been possible to achieve much progress so far. The member of the staff who had been devoting himself specially to such studies had been sent abroad for training in modern methods and returned recently.

The observations on populations of the pink and spotted bollworms of cotton were continued during the year.

Biological control of insect pests

At present the work in progress is mainly in relation to the pests of the sugarcane crop. As in previous years special attention was paid to *Trichogramma evanescens minutum* for the control of the Stem-borer of Sugarcane, and during the year about 12 million parasites were bred in the Parasite Laboratory; cultures of the host and parasites were supplied to centres whenever there was a "breakdown" in breeding in these localities.

The *Trichogramma* colonisation field experiments at Cuttack were continued. Large differences in parasitisation were observed between the treated and the control plots.

Studies were carried out on the longevity and fecundity of *Trichogramma*; the effect of different intensities of light on the reproduction of this parasite was also studied. Details will be found in the report of the Division of Entomology.

The mass-breeding of *Bracon (Microbracon) gelechiæ* was also carried out satisfactorily.

Insect vectors of virus diseases

Work on the insect vectors of virus diseases has been confined mainly to the transmission of the leaf-curl disease of tobacco the vector of which is the whitefly, *Bemisia tabaci*. The study of host plants of this vector was continued.

Pests of stored foodstuffs

Investigations in progress have been concerned mainly with pests of jowar, pulses and dried fruits.

Observations on the storage pests of jowar in the month of October 1947 showed that at 0° C. the adults of *Rhizopertha dominica* were rendered inactive but became

active when exposed to room temperature. The optimum temperature for *R. dominica* was between 31-36° C.

Bruchus infestation in pulses (broken and whole) shows least damage when they are stored in broken condition. Milling the pulses reduces the moisture content of the grains as well as the pupating space required for the development of the insect.

Studies of pests of dried fruits were continued.

Insecticides

Insecticides recommended for pest control should be cheap, effective, and easily applied, if they are to be adopted by the small cultivator. Also they should not be harmful to man and livestock or to beneficial insects. Synthesis and trial of new chemicals are being pursued with vigour in many countries. Also the possibilities of employing indigenous plant materials and other substances are being actively investigated. The value of many plant products such as pyrethrin, nicotine rotenone is well established as they have properties complementary to or not possessed by the synthetic chemicals. Often a mixture of both types is helpful. Steps for the development of suitable plant products should, therefore, be taken up simultaneously with that of synthetic chemicals.

In the previous year, work on the insecticidal properties of opium, opium mare and tobacco was carried out against general crop pests and stored grain pests to study their contact and insectifugal action. Further work was carried out this year with these and a new insecticide, extracted from the plant, *Adhatoda vasica*, to study their effect as stomach poison and as smoke.

Dust obtained from dry tobacco stems when mixed with hydrated lime in the ratio of 1 : 1 was found to have more lethal effect than 2% DDT in chalk against *Macrosiphum solidaginis*.

Experiments with other insecticides are underway. The method of preparation of the insecticide and the manner of its application also require research and experimental trials.

Assistance to Plant Protection and Quarantine Organization

The Institute continued to assist the newly-established Plant Protection and Quarantine Organization by providing accommodation in the Entomology and Mycology Laboratories at considerable inconvenience to itself, by permitting free access to and use of the insect collections and mycological herbaria, and the Library.

MYCOLOGY AND PLANT PATHOLOGY

Herbarium and Fungi Culture Collection

The *Herbarium Cryptogamæ Indiæ Orientalis* of the Division containing specimens of Indian fungi which was started at the time of E. J. Butler is well-known and now contains about 16,400 specimens. By the end of 1920, nearly 1,800 species had been collected, identified and some of them studied in detail. Since then a further large number has been added and studied. During the year 120 specimens were supplied to various research and teaching institutions both in India and abroad. Four *Exsiccati* sets, viz., *Fungi Dakotensis*, *Fungi Columbiani*, *North American Uredinales* and *Fungi Scandinaviæ* were added to the Herbarium.

The *Indian National Fungi Culture Collection* was maintained. Forty-one new cultures were added, while 111 cultures were supplied to various research Institutes, Universities and Industrial concerns, both in India and outside. Investigations into

improved methods of preservation of live-cultures were continued and it was observed that certain species of *Aspergillus*, *Penicillium*, *Helminthosporium*, *Alternaria* and *Curcularia* remained viable for eight months in culture tubes to which a sufficient quantity of liquid paraffin to cover the fungal growth had been added.

Fungal diseases of crops

The chief function of the Division has been the study of diseases of crop plants caused by parasitic fungi, with a view to devising measures for control. As in previous years, a good deal of attention was paid to the testing for disease resistance of strains of crop plants evolved in the Division of Botany, especially in respect of the smut diseases of wheat, the wilt disease of pigeon peas and the late-blight disease of potatoes.

Gram wilt

Last year a cooperative scheme of work was drawn up to investigate, from various angles, this and other serious diseases of the gram crop. Earlier work on the mycological aspects of gram wilt had given results which were confusing. The careful study of the various types of symptoms exhibited by apparently affected plants, was continued. Artificial inoculations indicate that *Fusarium orthoceras* is possibly responsible for the typical wilt disease. Investigations which are being simultaneously conducted in the Division of Chemistry suggest that more than one disease may be involved in the complex known as "gram wilt".

Pigeonpea wilt

Tests of pigeonpea strains evolved in the Division of Botany were continued. Out of 22 strains tested during the year, four appeared to be resistant. The percentage of infection in sterilised soil was again observed to be greater than in unsterilised soil. In this connection, a study of the microflora of the soil and their effect on parasitic activity has given indications that two isolates of bacteria exhibit a marked anti-biotic action on *Fusarium udum*, the causal organism of the disease.

Late-blight of potatoes

The testing of potatoes varieties bred at the Simla Substation was continued; out of 102 hybrids and cultures tested for resistance to Late Blight, 34 were found to be resistant.

Wheat Rust

The Division of Mycology has not hitherto paid much attention to the wheat rusts, work on which has been done almost solely by Dr. K. C. Mehta of Agra. The black rust epidemic of 1946-47, however, showed how important it was to the food position in this country to control the losses due to this source and to undertake the necessary studies to provide scientific data for devising control measures. The scheme for coordinated work on the problem throughout the wheat-growing areas of the country and at the Indian Agricultural Research Institute, to which reference was made in the previous report, has unfortunately not yet come into operation, being still under consideration. Experiments have however already been begun, on a small-scale to determine the effect of black rust on the yield of wheat.

At the request of the Government of India, experiments were conducted, with the cooperation of the Botany Division, to test the performance of shrivelled seeds from rust-affected wheat plants. Out of 187 samples of seed obtained from affected localities, 130 samples were recommended as suitable for seed purposes as they showed a germination

percentage of over 70 per cent. There were no appreciable differences in the yield of plants grown from rust-affected and normal seeds and the conclusion tentatively arrived at was that if the number of seeds per unit area is increased to compensate for the somewhat lower germination of the former seed, a yield can be obtained from the crop raised from rust-affected seed which is comparable to that from normal seed, provided the damage to the seed has not proceeded too far.

Safflower Rust

The life-history of safflower rust was studied. The rust was also found infecting wild safflower and it has been indicated that the rust in the following season originates from the over-summering teleutospores lying in the debris or mixed with the seed.

Sugarcane Diseases

Ninety-seven sugarcane varieties were tested for their resistance to the red-rot disease and to smut. Seven varieties proved highly resistant to the former, and eight varieties to the latter. Details will be found in the report of the Division of Mycology.

Aeroscope studies

The study of air-borne spores which was commenced in December 1946 was continued. A large number of spores of *Helminthosporium* and *Alternaria* was trapped. A spore of *Puccinia* was trapped for the first time in the third week of October. Viable uredospores of *P. graminis*, *P. rubigo-vera* and *P. glumarum* were caught during the month of January, almost 2-3 weeks before the appearance of rust on the standing crop in the Institute area.

Fungicides

It is obvious that fungicides must be both cheap and effective if they are to find favour with the Indian farmer, whose financial resources are exceedingly slender: there is therefore a need for testing our indigenous materials from this view point. The study, begun on a small scale last year, was continued and leaf extracts of *Calotropis gigantea*, *Boerhavia diffusa*, *Ocimum sanctum* and *Adhatoda vasica* were tested against *Helminthosporium halodea*, *Alternaria solani*, *Sclerotium rolfsii* and rusts. *Adhatoda vasica* showed fungicidal properties against all the fungi tested but was efficacious only at moderate concentration of the active principles.

Virus studies

One of the most striking developments in modern times in the domain of plant diseases has been the study of viruses which are now recognised to be responsible for some of the most important diseases of crop and garden plants. In Europe and America, great advances in the technique of virus study have been made especially in the use of physical and chemical techniques. In India, however, the subject has been comparatively neglected and what little has been done has been achieved (with one or two exceptions) in the absence of proper insect-proof glass-houses and modern equipment. Studies on the physical and chemical properties of viruses require costly equipment; this should, however, be made available at least at this Central Institute, for the benefit of the whole country.

The work on plant viruses and the diseases caused by them, which is being earned out at the Indian Agricultural Research Institute, has hitherto been restricted mainly to the potato crop, and has followed three chief lines, *viz.*, (i) the identification of virus diseases affecting the potato crop, (ii) the setting up of an organisation for producing

and multiplying certified potato seed, and (iii) the working of a scheme which aimed at making available immediately, as a contribution to the "Grow more food" scheme, comparatively disease-free stocks of seed potatoes, the method of securing this being a process of roguing-out of all severely diseased plants. Under the first head, it was mentioned last year that *Solanum* viruses 1, 2, 3, 4, 8, 9 and 14 had been identified. During the year under report attention was paid to a necrotic disease found in plants of the potato variety Darjeeling, Red Round, other kinds of potatoes, and virus diseases of sunnhemp, lettuce and bottleguard were also studied.

Under the second head, the results have been rather disappointing and it has not yet been possible to multiply or certify seed of any variety. A small quantity of apparently virus-free seed of Darjeeling, Red Round and Up-to-date has, however, been raised and will be multiplied further. Work was also begun to select virus-free nucleus stocks of Hybrids 2, 9 and 12 bred at the Simla Substation which have shown good performance when tried out at a number of centres in the hills. Under the third head, 3,026 maunds of partially disease-free potato seed were distributed to Provincial and State Governments. The crops raised from this seed are reported to have been very satisfactory.

It is understood that except for certain fundamental aspects the potato work referred to above, part of which has been financed by the Indian Council of Agricultural Research, will be taken over by the Central Potato Research Institute which is under contemplation.

Bacteria

The study of bacteria in relation to plant diseases has not received much attention hitherto in India. The reorganized and expanded programme of work of the Institute provision has been made for work on this subject in the Divisions of Mycology and Chemistry.

AGRICULTURAL ENGINEERING

General

The main lines of work laid down for the Division are:—

- (a) the improvement and modification of existing implements and methods,
- (b) the design of new and better implements and machinery which could be operated by bullocks or by simple power-driven prime movers, and
- (c) the adoption, after modification to suit Indian conditions, of new implements and machinery both of foreign and local make.

The work of the Division was again on a restricted scale on account of the non-availability, for the greater portion of the year, of suitable skilled and technical personnel and the lack of proper workshop facilities, not even the first portion of the proposed machine shop having yet been taken up for construction.

Equipment

The first instalment of certain machinery ordered from abroad for experiments in the design of small mills for use in rural areas for the utilization of sun-dried bones has arrived; also two small threshers now extensively used in Holland on small holdings. These will be subjected to trials with a view to ascertaining their economic and practical possibilities for usage under Indian conditions by peasants or groups of farmers.

During the course of the year a considerable quantity of equipment was purchased from Army Disposals. This included machine tools, hand tools, tool sets, welding equipment, air-compressor, battery charger, portable electric generators, small horse-power petrol engines, etc.

Tractors

Extensive field trials were carried out with various types of tractors, over periods exceeding one thousand hours. The results are given in tabulated form in the full report of the Division and the figures given there may be useful as a general guide regarding tractor operating rates.

With the object of investigating the possibilities of operation in this country of low H.P., air-cooled walking-type tractors, experiments were carried out on a "Gravely" 5 H.P. tractor. After a running period of less than 150 hours the tractor required a major overhaul due to excessive engine wear. Other weaknesses in design showed themselves during the test which was carried out in shade temperatures varying from 90°—110° F.

Water-pumps

Further tests were conducted on a small 1-horse power centrifugal pump obtained from abroad previously. This is a self priming pump costing about Rs. 50 and is capable of delivering 50 to 75 gallons of water per minute for a lift of about 20 feet. It is now driven by a 1-horse power petrol engine. This engine will operate for about seven hours on one gallon of petrol. Experiments will be continued to operate this pump by bullocks through the medium of a bullock gear which also is being developed in this Institute.

Kans eradication

The results for 1947-48, *i.e.*, the second year of working of the scheme at Bhopal have not yet been received. A consolidated report will be prepared as soon as these are obtained.

Miscellaneous

Initial experiments were carried out to investigate the advantages of filling tyres fitted on country carts with water in lieu of air. These have so far given remarkable results and it is proposed to conduct full-scale trials during the coming year.

A rotary screen was devised to deal with decomposed material available in large quantities in all town refuse dumps. Under tests the screen produced, by manual labour, 80—100 maunds per hour of finished material which by chemical analysis compared well with good quality compost.

III.—GENERAL ADMINISTRATION

Charge

Dr. J. N. Mukherjee continued to hold the post of Director of the Institute.

Dr. B. P. Pal, Head of the Division of Botany, continued to hold the post of Assistant Director, except for 46 days when he was on earned leave as stated in the following paragraph and Major Brown officiated as Assistant Director.

Mr. N. C. Pal, took over charge of the newly-created post of Registrar of the Institute on the forenoon of 17th October, 1947.

Staff

The Divisions of Botany, Agricultural Engineering, and the Sugarcane Substation, Coimbatore, remained throughout the year under the charge of Dr. B. P. Pal, Major D. T. Brown and Mr. N. L. Dutt respectively, except that when Dr. Pal was on earned leave for 46 days from 4th February, 1948, to 20th March, 1948, Dr. N. Parthasarathy was incharge of the Botany Division and when Mr. Dutt was on leave on average pay for two months from 26th November, 1947 to 25th January, 1948, Mr. M. K. Krishnaswami was incharge of the Coimbatore Substation. Mr. C. H. Parr held charge of the Division of Agronomy upto 15th July, 1947, when he proceeded on leave preparatory to retirement. Dr. P. C. Raheja held charge of this Division from 15th July, 1947, to 27th November, 1947, when Dr. T. J. Mirchandani took over charge of the Division.

Dr. S. V. Desai was incharge of the Division of Soil Science and Chemistry upto 15th March, 1948, when he proceeded on leave for 28 months and Director took over charge of the Division in addition to his own duties. Mr. J. F. Dastur officiated as Head of the Mycology Division upto 30th September, 1947, when Dr. R. S. Vasudeva took over charge of the Division in addition to his own duties. The latter was appointed as officiating Head of the Mycology Division from 22nd June, 1948. Dr. E. S. Narayanan took charge of the Division of Entomology on 1st August, 1947, in addition to his own duties as Parasitologist from Dr. T. Ahmed who opted for Pakistan. He was appointed officiating Head of the Entomology Division on 22nd June, 1948. A list of gazetted staff together with such changes as occurred in the different Divisions is given in Appendix I.

The following Research Schemes financed by the Indian Council of Agricultural Research and the Indian Central Sugarcane Committee as noted against them continued functioning at the Institute:—

I. C. A. R. Schemes.

- (1) D. D. T. Scheme.
- (2) Compost Scheme.
- (3) Scheme for Fumigation Technique against Codling Moth.
- (4) Seed Potato Multiplication Scheme.
- (5) Schools of Research in Entomology.
- (6) Scheme for Minor or Trace Elements in Indian Soils.
- (7) Pulse Scheme.
- (8) Jowar Scheme.
- (9) Colloid Soil Constituents Scheme.
- (10) Nitrogen Fixation in Soils Scheme.
- (11) Seed Potato Certification Scheme.
- (12) Potato Breeding in Northern India, Simla, including Bhowali Hill Station.
- (13) Economic Plants Scheme.
- (14) Breeding rust resistant wheat in the hills Scheme.
- (15) Maize Scheme.
- (16) Schools of Research in Mycology.

I. C. S. C. Schemes.

- (1) Spontaneum Expedition Scheme.
- (2) Sugarcane Physiology Scheme, Coimbatore.
- (3) Diseases of Sugarcane Scheme.
- (4) Insect Pests of Sugarcane.

- (5) Additional staff for Sugarcane Breeding Station, Coimbatore.
- (6) Karnal Sugarcane Substation.

The following schemes financed by the Government were also in progress:—

- (1) Kans Control Scheme.
- (2) Palmyra Palm Scheme.

Training

95 applications were received in all for admission to the post graduate and Plant Protection courses beginning from October, 1947. 49 were selected for admission; 16 in Agriculture, 3 in Sugarcane Agronomy, 10 in Botany, 6 in Chemistry, 6 in Entomology and 8 in Mycology. 34 students completed the two-year post graduate courses during the year and were awarded the Institute diploma; 9 in Agriculture, 3 in Sugarcane Breeding, 5 in Botany, 7 in Chemistry, 3 in Entomology and 7 in Mycology. Five students completed the one-year course in Plant Protection. Facilities were afforded to a number of short course students and honorary research workers as shown in Appendix II. Four Research Fellows paid at Rs. 150 per mensem were working during the year. Of these three were associates of this Institute.

Library

The total number of publications received in the Library both by way of exchange and by purchase was 2,849; thirty-eight new periodicals were added during the year. 4,436 books were issued out on loan during the period under report of which 1,004 were sent to Scientific Workers in the Provinces and the Universities. 7,974 visitors made use of the Reading Room and consulted 97,228 books during the year.

IV.—ACCOUNTS

The total expenditure of the Institute and its Substations at Karnal, Coimbatore and Pusa during the financial year ended 31st March, 1948, amounted to Rs. 15,69,421 and the total receipts to Rs. 2,61,776. A further expenditure of Rs. 26,994 was also incurred on account of the undermentioned two temporary Schemes sanctioned by the Government of India which were financed from the Central Revenues:—

	Rs.
General expenditure of the Institute including the Office of the Director,	
Irrigation, Power Supply, Gas Plant and Estate Establishment ...	3,33,659
Division of Agronomy. ...	2,72,776
Division of Mycology. ...	85,927
Division of Entomology. ...	89,680
Division of Soil Science & Agril. Chemistry. ...	1,90,328
Division of Botany. ...	1,01,335
Division of Statistics. ...	6,842
Division of Agricultural Economics. ...	54
Division of Agricultural Engineering ...	1,51,342
Sugarcane Breeding Station, Coimbatore. ...	1,24,924
Total Expert Staff & Directorate ...	13,56,867

Experimental farms.

Agricultural Substation, Karnal	...	...	...	...	1,72,608*
Botanical Sub-station, Pusa.	...	...	...	...	39,946**
Total Experimental Farms.	...	...	...	...	2,12,554
Grand Total of expenditure	...	...	...	...	15,69,421

Schemes financed by the Government of India.

Kans Control Scheme.	...	...	...	...	25,105
Central Seed Testing Scheme.	...	...	...	...	1,889
	...	...	...	...	26,994

The expenditure of the various Research Schemes financed by the Indian Council of Agricultural Research and the Indian Central Sugarcane Committee amounted to Rs. 1,51,077 and Rs. 77,956 respectively as shown below:—

Schemes financed by the Indian Council of Agricultural Research.

	Rs.
Potato and Wheat Breeding Substation, Simla.	51,801
Scheme for Research on Storage of Jowar.	1,514
Seed Potato Certification Scheme.	16,075
Seed Potato Multiplication Scheme.	48,523
Scheme for Research on Storage of Pulses.	2,067
Scheme for Research into the properties of Colloid Soil Constituents.	1,564
Scheme for Research on Minor or Trace Elements in Indian Soils and Plant Nutrition.	4,535
Scheme for Introduction of Economic Plants.	5,707
Scheme for Improvement of Maize Crop in India.	2,757
School of Research in Entomology.	6,682
Scheme for Fumigation of Imported Fruits for Control of Codling Moth.	5,674
Scheme for Research on Nitrogen Fixation in Soils by Legumes.	2,369
School of Research in Mycology.	1,100
Compost Scheme.	709
TOTAL	1,51,077

Schemes financed by the Indian Central Sugarcane Committee.

	Rs.
Sugarcane Substation, Karnal.	12,605
Scheme for Research on Diseases of Sugarcane.	3,974
Scheme for Research on Biological Control of Sugarcane Pests.	14,243
Scheme for Research on Physiology of Sugarcane.	17,051
Scheme for Additional Staff for Sugarcane Breeding Station, Coimbatore.	19,800
Spontaneum Expedition Scheme.	10,283
TOTAL	77,956

The receipts of the Institute and its different Substations amounted to—

	Rs.
Main Institute.	1,27,311
Sugarcane Breeding Station, Coimbatore.	14,804
Agricultural Substation, Karnal.	1,13,744*
Botanical Substation, Pusa.	5,916**
TOTAL	2,61,775

*Vide Income and Expenditure Accounts reproduced below.

Income and Expenditure Account for the year ended 31st March, 1948.

INCOME					Rs.
1.	By sale of Dairy Produce.	...	...	...	62,693
2.	By sale of Farm Produce.	...	...	...	46,326
3.	Miscellaneous Receipts.	...	...	...	1,755
4.	Live Stock.	...	...	...	2,970
TOTAL					1,13,744

EXPENDITURE					Rs.
1.	Pay of Officers and Establishment.	...	...	...	29,261
2.	Travelling Allowance.	...	...	...	963
3.	Dearness Allowance.	...	...	...	32,903
4.	Feed of Dairy Cattle, etc.	...	...	...	15,836
5.	Workshop.	...	...	...	1,925
6.	Production of Grain & Fodder.	...	...	...	68,615
7.	Fuel, Light, Water, etc.	...	...	...	4,842
8.	Miscellaneous contingencies.	...	...	...	5,012
9.	Repairs to Plant and Machinery.	...	...	...	9,659
10.	Petty Constructions & Repairs.	...	...	...	831
11.	Purchase of Cattle, Land & Machinery.	...	...	...	711
12.	Equipment.	...	...	...	2,050
TOTAL					1,72,608

**INCOME					Rs.
	By sale of Farm produce.	...	...	...	5,916

EXPENDITURE					Rs.
	Pay of Officers.	...	...	...	1,075
	Pay of Establishment.	...	...	...	5,889
	Travelling Allowance.	...	...	...	554
	Dearness & Other Allowances.	...	...	...	4,138
	Plant Breeding.	...	...	...	23,979
	Apparatus.	...	...	...	1,240
	Miscellaneous.	...	...	...	2,771
TOTAL					39,946

Report of the Head of the Division of Agronomy

I.—AGRONOMY

1. Season and crops

The monsoon and the winter precipitations were above the normal. The total rainfall during the year from July 1947 to June 1948 was 25.79" as against 15.49 inches and 30.26 inches during the corresponding periods in 1946-47 and 1945-46. The monsoon (June to October) and the winter (November to April) rainfalls amounted to 20.14 and 4.14 inches respectively as against 17.06 and 2.27 inches in the corresponding periods in 1946-47. The monsoon reached somewhat late and no good shower was received in July 1947. The kharif crops could not, therefore, be sown in time, as it was not possible to deal with the whole area quickly for the *kharif* sowing with presowing irrigation. The heavy rains in September amounting to 12.41 inches caused waterlogging in many fields and most of the standing *kharif* crops were affected adversely. The *rabi* sowing in many fields was delayed considerably owing to the very wet condition of the land which could not be ploughed in time for the preparation of seed bed, and inspite of good and well distributed winter rains which were favourable for the growth of all *rabi* crops, the yields in most cases were below the average.

TABLE I.
Meteorological data for the year 1947-48.

Month.	Mean Temperature.		Relative humidity % (7.21 A.M.)	Rainfall inches.	No. of rainy days.
	Maximum ° F.	Minimum ° F.			
July, 1947 ...	100.0	84.3	77.7	2.53	9
August, 1947 ...	95.1	83.0	79.0	4.79	12
September, 1947 ...	93.9	74.9	90.9	12.41	16
October, 1947 ...	88.8	62.7	84.4	0.40	2
November, 1947 ...	84.3	54.9	81.4	0.00	0
December, 1947 ...	71.5	44.6	85.0	0.26	3
January, 1948 ...	67.7	45.1	93.7	1.85	6
February, 1948 ...	70.7	46.7	86.0	1.03	5
March, 1948 ...	78.6	52.6	84.9	1.00	4
April, 1948 ...	98.1	66.2	53.6	0.00	0
May, 1948 ...	105.4	75.3	42.5	0.49	5
June, 1948 ...	105.1	81.4	47.4	1.03	5
TOTAL ...	...	...	...	25.79	67

2. Seed Supply

Seeds of improved varieties of wheat, barley, gram, peas, oats, maize and soyabean were supplied to meet local and outside demands. The total quantity of seed distributed during the year under report was 6,567.5 lb.; sugarcane setts weighing 38.2 tons were also distributed to local cultivators.

3. Work on sugarcane

Sugarcane was grown on an area of 4.75 acres. An area of 2.5 acres was planted to Co. 312 for the Division of Entomology for the study of sugarcane pests and control of white ant. Several varieties were also grown for the Division of Mycology in connection with the study of mosaic disease. Co. K. 26, Co. K. 30, Co. 312, Co. 356, Co. 421, Co. 453, Co. 622, Co. 634, Co. 636, Co. 637, Co. 638 were grown for the multiplication of seed material. Eighty-eight varieties, including 15 newly imported varieties from Coimbatore, viz., Co. 645 to Co. 659 were planted in the nursery for observation and multiplication.

4. Agronomic Experiments

A.—MANURIAL EXPERIMENTS

(a) Nitrogenous manures and fertilizers

In one of the experiments in which the relative value of nitrogen in organic and inorganic manures is being tested, the yields of wheat showed significant differences due to treatments. Farmyard manure gave best yields and this was followed by green manuring with cowpeas, leaf compost and castor cake treatments. In another experiment the manurial values of farmyard manure and castor cake were assessed against complete fertilizer treatment, keeping the quantities of N, P_2O_5 and K_2O constant in all the treatments. The complete fertilizer treatment gave the maximum yield of wheat and this was significant over the organic manures.

(i) *Experiment to test the relative values of nitrogen in organic and inorganic manures.*—This experiment started in 1944-45 gave significant results during the year under report. The comparative results of the past four years are given in Table II.

TABLE II.

Yield of wheat N.P.165 in maunds per acre.

Treatment per acre.				Yield of wheat grain.			
				1944-45.	1945-46.	1946-47.	1947-48.
A.	Sannhemp green manure	...	...	28.1	20.7	13.9	15.4
B.	Cowpeas green manure	...	...	31.2	20.2	15.5	16.4
C.	Rape cake 40 lb. N.	...	...	31.0	22.4	16.4	15.7
D.	Castor cake 40 lb. N.	...	...	32.3	20.5	16.3	16.1
E.	F. Y. M. 40 lb. N.	...	...	33.4	20.0	14.5	17.7
F.	Leaf compost 40 lb. N.	...	...	29.1	20.5	19.0	16.4
G.	Am. sulphate 40 lb. N.	...	...	26.7	22.2	17.7	9.6
H.	No manure (control)	...	...	27.3	19.3	17.6	12.4
Critical difference (5%)				5.18	2.51	3.59	1.82

Conclusion.—1944-45 : E, D, B, C, F, A, H, G.

1945-46 : C, G, A, D, F, B, E, H.

1946-47 : F, G, H, C, D, B, E, A.

1947-48 : E, B, F, D, C, A, H, G.

A comparison of the four years' results shows that they were not consistent throughout the period. During the year under report best yields were obtained from the F. Y. M., cowpeas green manuring, leaf compost and castor cake treatments. Am. sulph. alone, which was applied one month after sowing, gave negative results. This is being looked into.

(ii) *Soil fertility experiments*.—The objective of these experiments started last year is to see the effect of different nitrogenous manures with phosphate and potash with and without legume in rotation on the soil fertility. In one series, the rotation adopted is wheat-maize, while in the other it is wheat-maize—peas-maize. The first crop of wheat was grown in *rabi* 1946-47 in both the series and this was followed by maize in *kharif* 1947 and wheat and peas in *rabi* 1947-48. The *rabi* crops only were manured. The first crop of wheat lodged badly and the results were not consistent with manurial treatments. The results with the crops grown in 1947-48 are given in Table III.

TABLE III.
Yield of grain in maunds per acre.

Treatment per acre.	Rotation without legume.		Rotation with legume.	
	Maize No. 2	Wheat C.518	Maize No. 2	Peas N.P.29
A. No manure	18.8	11.9	16.8	19.4
B. Am. sulph. 60 lb. N+super 100 lb. P_2O_5 + S. pot. 100 lb. K_2O	20.6	14.6	11.9	19.9
C. F. Y. M. 60 lb. N+ P_2O_5 + K_2O as in 'B' making allowance for these in F. Y. M. ...	18.3	12.5	12.9	20.9
D. Castor cake 60 lb. N+ P_2O_5 and K_2O as in 'B', making allowance for these in cake.	21.9	12.9	14.6	19.9
Critical difference (5%)	6.06	1.77	8.67	2.02

The maize yields were affected due to heavy rains in September and the results were not consistent according to the treatments. In the *rabi*, only the wheat yields showed significant differences due to treatments. Best results were obtained with complete artificials. The yields of peas, though showed slight increases due to treatments, were not significant.

(b) Phosphatic fertilizers

A large number of experiments are in progress to study the response of phosphatic fertilizers on the yield of different legumes and the after-effects on the subsequent cereal crops. The two old experiments started in 1940-41 and 1941-42 had fifth and fourth unmanured crops of wheat, since berseem had its last manuring, to see the after effects of berseem grown with phosphates. During the year under report, there was not much difference between the phosphate treated and the control plots. In the case of high doses of phosphate (1940-41 experiments), the after effects were significant on four crops of wheat grown consecutively. Similarly, in the other experiment in which low doses of phosphate were applied, three consecutive crops of wheat gave increased yields due to phosphate treatment of berseem.

In experiment with cowpeas, farmyard manure with phosphate gave increased yield of fodder and the following crop of wheat also gave increased yield under the same treatment.

In another experiment in which the effect of different forms of phosphates, such as superphosphate, ammonium phosphate, bonemeal and basic slag is being studied, wheat

was grown to study the after-effects of phosphate manured berseem. Plots treated with ammonium phosphate gave highest yields of wheat. The combination of phosphate with farmyard manure also gave very good results.

(i) *Berseem manurial experiment No. 1.*—In this experiment, started in 1940-41, berseem was manured as detailed in Table IV for three consecutive years. In the intervening *kharif* seasons, cowpeas were grown for fodder without manuring. From 1943-44, unmanured wheat is being grown in two rotations (a) fallow-wheat and (b) cowpeas or *guar*-wheat, to study the nature of fertility built up by phosphate manuring of berseem. The results obtained in 1947-48 are given in Table IV.

TABLE IV.
Yield of guar green fodder and wheat C518 grain in maunds per acre.

Treatment per acre (applied to berseem).				Guar 1947.	Wheat after Guar.	Wheat after 4 fallows.	Wheat after 5 fallows.
A.	F. Y. M.	40 lb. N	...	63.7	14.8	21.2	11.4
B.	F. Y. M.	80 lb. N	...	46.3	12.7	25.5	14.8
C.	F. Y. M.	120 lb. N	...	46.1	13.8	26.5	15.9
D.	Activated sludge	80 lb. N	...	50.6	12.1	14.1	18.6
E.	Mustard cake	80 lb. N	...	48.2	11.7	16.9	21.4
F.	Am. sulph.	80 lb. N	...	54.5	15.5	24.5	15.2
G.	Super 132 lb.	P ₂ O ₅	...	62.1	16.5	23.8	12.1
H.	Super 198 lb.	P ₂ O ₅	...	73.1	21.0	15.9	20.0
I.	Super 264 lb.	P ₂ O ₅	...	77.4	23.8	13.1	14.8
J.	F. Y. M.	80 lb. N+super 132 lb.	P ₂ O ₅	72.5	20.0	27.2	21.7
K.	Complete artificials on the basis of 'B'			74.5	16.9	27.5	10.7
L.	No manure			52.7	11.7	15.5	13.8
Critical difference (5%)				25.63	9.97	12.7	13.13

The results due to treatments were not significant, except in the case of wheat grown after *guar* where treatment I showed significant differences over C, B, A, E and L.

(ii) *Berseem manurial experiment No. 2.*—This experiment was started in 1941-42, on the same lines as in experiment No. 1 detailed above, with small doses of phosphate. The results obtained during the year under report are given below.

TABLE V.
Yield of guar green fodder and wheat C.518 grain in maunds per acre.

Treatment per acre (applied to berseem).				Guar 1947.	Wheat 1947-48.		
					After guar.	After fallow.	
A.	F. Y. M.	16 lb. P_2O_5	...	...	63.9	7.0	21.6
B.	F. Y. M.	32 lb. P_2O_5	...	...	105.0	17.8	26.2
C.	F. Y. M.	64 lb. P_2O_5	...	...	80.4	12.6	17.6
D.	Super.	16 lb. P_2O_5	...	...	75.6	11.3	17.9
E.	Super.	32 lb. P_2O_5	...	...	55.5	6.3	24.7
F.	Super.	64 lb. P_2O_5	...	...	70.0	15.2	23.1
G.	Super.	8 lb. P_2O_5 +F. Y. M.	8 lb. P_2O_5	...	110.3	18.1	23.4
H.	Super.	8 lb. P_2O_5 +F. Y. M.	24 lb. P_2O_5	...	92.1	12.3	24.0
I.	Super.	8 lb. P_2O_5 +F. Y. M.	56 lb. P_2O_5	...	77.3	11.3	22.7
J.	Super.	24 lb. P_2O_5 +F. Y. M.	8 lb. P_2O_5	...	70.6	6.5	23.4
K.	Super.	56 lb. P_2O_5 +F. Y. M.	8 lb. P_2O_5	...	90.7	15.5	22.8
L.	No manure	...	...	...	67.5	6.8	19.1
Critical Difference (5%)				...	24.47	4.84	8.74

In regard to *guar* yields, treatments G, B and H showed significant difference over the control. In the case of wheat after *guar*, treatments G, B, K, F, C and H gave significant yields over the control, but wheat after fallow did not show any significant differences among the treatments.

(iii) *Direct and indirect manuring of wheat in a cowpea-wheat rotation.*—In this experiment, which is in progress since 1944-45, cowpeas is manured every year to study the after-effect on the following crop of wheat as against the effect of direct manuring of wheat. The yields of cowpeas and wheat obtained in 1947-48 are given in the table below:—

TABLE VI.

Yield of cowpeas green fodder and wheat C518 grain in maunds per acre.

Treatment per acre.						Cowpeas.	Wheat.
<i>Applied to cowpeas.</i>						1947.	1947-48.
A.	F. Y. M.	80 lb. P_2O_5	...	...	...	150.6	13.1
B.	Super	66 lb. P_2O_5	...	...	...	106.7	9.5
C.	Super	198 lb. P_2O_5	...	...	...	127.6	9.7
D.	F. Y. M.	40 lb. P_2O_5 + Super	33 lb. P_2O_5	...	...	120.8	10.9
E.	F. Y. M.	40 lb. P_2O_5 + Super	99 lb. P_2O_5	...	...	136.1	12.2
F.	F. Y. M.	80 lb. P_2O_5 + Super	66 lb. P_2O_5	...	...	165.0	15.8
G.	F. Y. M.	80 lb. P_2O_5 + Super	198 lb. P_2O_5	...	...	141.4	12.6
<i>Applied to wheat.</i>							
H.	Super	66 lb. P_2O_5	...	...	...	113.3	11.4
I.	Super	198 lb. P_2O_5	...	...	...	126.1	9.5
J.	Am. sulph.	80 lb. N.	...	...	...	121.9	13.5
K.	No manure	...	...	...	...	116.9	9.8
Critical difference (5%)						22.09	2.91

The highest yield of cowpeas was obtained from treatment F and the wheat yield following this was also highest. Treatments A, F and G showed significant differences over the control, both in the case of cowpeas and wheat. The direct manuring of wheat with am. sulphate also gave significant increase in yield.

(iv) *Phosphate manuring of berseem with and without potash.*—The object of this experiment is to study the differential response of phosphates in combination with different levels of potash on the yield of berseem and after-effects on the yield of maize and wheat. Berseem was grown in *rabi* 1946-47 which was followed by unmanured maize and wheat during the year under report. Berseem yields showed that phosphates, am. phosphate and superphosphate were effective when applied at 160 lb. P_2O_5 per acre. Potash at 80 lb. K_2O per acre in combination with phosphates gave significant results. The maize

crop of kharif 1947 failed on account of excessive rains in September. The yields of wheat N.P. 165 are given below :

TABLE VII.
Yield of wheat N.P.165 in maunds per acre.

Main plot treatment per acre.	Sub-plot treatments per acre.			Average.
	No manure	Pot. sulph. 40 lb. K_2O	Pot. sulph. 80 lb. K_2O	
A. Am. phosphate 80 lb. P_2O_5 ...	14.0	13.4	16.4	14.6
B. Am. phosphate 160 lb. P_2O_5 ...	11.0	11.6	11.6	11.4
C. Super 80 lb. P_2O_5 + Am. sulph. N as in 'A'	12.7	12.0	12.6	12.4
D. Super 160 lb. P_2O_5 + as in 'B'	14.2	10.5	14.8	13.2
E. Super 80 lb. P_2O_5 ...	12.3	13.9	12.3	12.8
F. Super 160 lb. P_2O_5 ...	13.6	10.9	11.6	12.0
G. No manure ...	6.9	7.9	7.1	7.3
Average ...	12.1	11.5	12.4	...

Critical difference (5%) for main-plot treatments = 3.3.

Critical difference (5%) for sub-plot treatments = 1.2.

Critical difference (5%) for treatment combinations = 3.2.

It will be seen from the above table that all main-plot treatments show significant differences over the control. The differences among the subplot treatments are not significant. In regard to treatment combinations, those with 80 lb. K_2O in general, have shown better effect than the others.

(v) *Phosphate manuring of berseem with and without organic manures.*—This experiment was started in 1944-45 when berseem was manured as shown in the table below. This was followed by unmanured crops of maize, wheat, maize and berseem. Highest yields of crops were obtained in the farmyard manure series with Am. phosphate. In the year under report, berseem was again manured as in 1944-45 and it is proposed to follow the same cropping system as before. The yields of berseem are given below :

TABLE VIII.
Yield of green berseem in maunds per acre.

Treatment per acre.	Sannhemp G. M.	Main treatment per acre.	
		F. Y. M. 10 tons.	No manure.
A. No manure ...	647.4	846.0	512.5
B. Super 120 lb. P_2O_5 ...	698.8	782.7	500.7
C. Bonemeal 120 lb. P_2O_5 ...	848.0	815.5	609.4
D. Am. phosphate 120 lb. P_2O_5 ...	763.0	911.9	642.4
E. Bonemeal & Am. phosphate each 60 lb. P_2O_5 ...	793.5	846.9	662.6
F. Bonemeal & super each 60 lb. P_2O_5 ...	687.3	859.8	640.3
Critical difference (5%) ...	55.32	48.76	17.72

In the 'green manure' series, treatments C, D, and E showed significant differences over the control, while in the 'farmyard manure' series only Am. phosphate was significant over the control. In the case of 'no manure' series, all the treatments, except super, gave significant results.

(vi) *Phosphate manuring of cowpeas.*—In this experiment, started last year, the study of the responses of cowpeas to direct manuring and of the after-effect on wheat is being made. After the harvest of cowpeas, the stubbles were buried in one set of plots with the application of Am. sulphate at 40 lb. N per acre to hasten decomposition of the stubbles. The wheat crop in this series was very vigorous and ultimately lodged giving poorer yield than that grown without nitrogen. The results obtained during the year under report are given below :—

TABLE IX.

Yield of cowpea hay and wheat C.228 grain in maunds per acre.

Treatments per acre.				Cowpeas 1947.	Wheat 1947-48. Am. sulph series.	No nitrogen series.	Average of nitrogen and no nitrogen series.
A.	No manure	...	...	59.6	16.4	21.7	19.1
B.	Am. sulph. 40 lb. N	...	...	61.6	19.0	22.7	20.8
C.	Super 120 lb. P_2O_5	...	...	63.4	19.1	24.1	21.5
D.	B+C	...	...	59.4	18.7	21.4	20.0
E.	C+pot. sulph. 80 lb. K_2O	...	...	63.3	17.3	27.3	22.3
F.	E+lime 10 mds.	...	...	59.2	22.8	24.5	23.6
G.	Am. sulph. 40 lb. N+F	...	...	63.0	21.1	25.5	23.2
	Average	...	...	...	18.7	23.8	...
Critical difference (5%) for cowpea hay yields				...	...	5.87	...
Critical difference (5%) for nitrogen and no nitrogen series (wheat)				...	...	3.29	...
Critical difference (5%) for phosphate, etc., treatments (wheat)				...	...	4.88	...
Critical difference (5%) for treatment com- binations (wheat)				...	...	6.60	...

The difference between nitrogen and no nitrogen series is significant, the low yield in nitrogen series is due to lodging of the crop. The phosphate treatments, though the differences among them are not significant, show higher yields than the control, the complete fertilizer treatment giving best results.

(vii) *Efficiency of different forms of phosphates.*—The object of this experiment is to test the effect of different forms of phosphates in combinations with other manures on berseem and after-effects on maize and wheat. Berseem was manured in *rabi* 1946-47. The results showed that plots treated with am. phosphate, superphosphate and basic slag gave higher yields of berseem than the control. The combination of farm-yard manure with phosphate was more effective than other combinations. The results

TABLE X.
Yield of maize No. 2 green fodder and wheat C.518 grain in maunds per acre.

The after-effects due to farmyard manure on both maize and wheat are significant. The subplot treatments are not significant in the case of maize, but in wheat all the treatments are significant over the control. The treatment combinations F.Y.M. and super. F.Y.M. and am. phos., am. sulph. and am. phos. gave significant yields of wheat.

(vii) *Phosphorus manuring of berseem* (New series I, II and III).—As stated in the last years report, these experiments were started with a view to obtaining confirmatory data regarding the beneficial aftereffects of phosphate manuring of berseems on the subsequent crop of wheat. Berseem was manured in *rabi* 1946-47 and it was followed by *guar* and wheat in Series I and fallow-wheat in Series II. The *guar* crop was destroyed due to waterlogging in *kharrif* 1947. The yield of wheat crop in Series II could not be recorded as sheaves of wheat of different plots got mixed by stormy wind after harvest. The wheat yields of Series I are given below: The results with berseem were not significant in 1946-47.

TABLE XI.
Yield of wheat C.518 in maunds per acre.

	Treatment per acre.						Wheat 1947-48.
A.	No manure	...	...	...	...	...	16.2
B.	Super 60 lb. P_2O_5	...	...	...	...	...	18.3
C.	Super 120 lb. P_2O_5	...	...	...	...	...	18.5
D.	Super 60 lb. P_2O_5 +pot. sulph. 80 lb. K_2O	...	...	...	...	...	17.1
E.	Super 120 lb. P_2O_5 +pot. sulph. 80 lb. K_2O	...	...	...	...	...	17.2
F.	Am. Sulph. 30 lb. N+Super 60 lb. P_2O_5 +pot. sulph. 80 lb. K_2O	...	...	...	...	...	18.9
G.	Am. Sulph. 30 lb. N+Super 120 lb. P_2O_5 +pot. sulph. 80 lb. K_2O	...	...	...	...	...	19.0
H.	Am. Sulph. 30 lb. N+Super 60 lb. P_2O_5	...	...	...	...	...	17.2
I.	Am. Sulph. 30 lb. N+Super 120 lb. P_2O_5	...	...	...	...	...	17.5
J.	F. Y. M. 30 lb. P_2O_5	...	...	...	...	...	17.2
K.	F. Y. M. 60 lb. P_2O_5	...	...	...	...	...	18.6
	Critical difference (5%)	...	...	...	...	...	3.8

Though the differences among the treatments were not significant, treatment 'G', NPK showed the maximum yield of wheat.

In Series III, it is proposed to follow berseem—*guar* rotation for 3 years and then grow wheat to study the after effects of phosphate manured berseem. The yields of manured berseem for 1947-48 are shown below. The *guar* crop of *kharif* 1947 was destroyed due to waterlogging.

TABLE XII.
Yield of green berseem in maunds per acre.

Treatments per acre.								Berseem 1947-48.
A. No manure	...	...	...	...	...	...	...	577.6
B. Super 50 lb. P_2O_5	...	...	...	...	...	...	...	645.1
C. Super 100 lb. P_2O_5	...	...	...	...	...	...	...	641.7
D. Super 50 lb. P_2O_5 + pot. sulph. 80 lb. K_2O	...	...	...	...	...	...	...	627.0
E. Super 100 lb. P_2O_5 + pot. sulph. 80 lb. K_2O	...	...	...	...	...	...	...	627.2
Critical difference (5%)	...	...	...	...	...	...	...	58.87

Treatment B and C showed significant differences over the control.

(ix) *Berseem manurial experiment with maize and cotton in the rotation.*—In this experiment, it is proposed to study the after-effects of phosphate manured berseem on maize and cotton grown in rotation. The rotation followed is: berseem (manured)-maize-berseem (manured)-cotton. The two phases of the rotation are represented separately in two blocks. During the year under report the cotton crop failed due to waterlogging. The yields of maize grown in *kharif* 1947 after berseem and those of manured berseem grown in *rabi* 1947-48 following maize and cotton are shown in Table XIII.

TABLE XIII.
Yield of maize No. 2 grain and berseem green fodder in maunds per acre.

Treatment per acre (applied to berseem)				Berseem 1947-48.		
				Maize. 1947.	After cotton.	After maize.
A. No manure	...	...	...	13.7	548.6	556.7
B. Super 120 lb. P_2O_5	...	...	...	14.9	710.0	633.0
C. Super 120 lb. P_2O_5 + pot. sulph. 120 lb. K_2O	...	...	...	15.0	726.7	646.6
D. Am. phosphate 120 lb. P_2O_5	...	...	...	15.1	763.9	747.6
E. Am. phosphate 30 lb. P_2O_5 + 90 lb. P_2O_5 super	...	...	...	12.8	736.4	657.2
F. Am. phosphate 60 lb. P_2O_5 + 60 lb. P_2O_5 super	...	...	...	13.2	751.8	680.1
Critical difference (5%)	...	...	...	3.72	32.20	46.54

From the above results, it will be seen that although the maize yields due to after-effects of phosphate manured berseem were not significant, treatments D, C and B gave encouraging results. In the case of berseem, all the treatments showed significant differences over the control, the highest yield was obtained from am. phosphate treated plots.

(x) *Direct and indirect manuring of cereals in rotation with rabi legumes.*—This experiment was started in 1946-47 to study the response of *rabi* legumes to phosphate manuring and compare the after-effects with direct manuring of maize and wheat. The *rabi* legumes included in the experiment were *senji* and *methra* for fodder and gram and peas for seed. The results obtained last year showed significant effect of phosphate alone or in combination with N and K in increasing the yields of the *rabi* legumes.

The results obtained with maize and wheat during the year under report were as follows :—

TABLE XIV.

Yield of maize No. 2 green fodder and wheat N.P.165 grain in maunds per acre.

Treatment per acre.	Previous legumes grown in 1946-47.							
	Peas	N.P.29.	Gram N.P.58.		Senji.		Methra.	
	Maize.	Wheat.	Maize.	Wheat.	Maize.	Wheat.	Maize.	Wheat.
	1947.	1947-48.	1947.	1947-48.	1947.	1947-48.	1947.	1947-48.
A. Am. sulph. 40 lb. N to cereals ...	104.5	10.4	108.8	13.1	108.4	10.9	141.8	11.3
B. Super 120 lb. P_2O_5 to legumes ...	113.5	5.7	69.7	8.5	96.9	9.1	108.7	7.0
C. B+Am. sulph. 40 lb. N to legumes ...	106.5	5.6	81.1	9.1	91.8	8.8	137.5	9.1
D. C+pot. sulph. 80 lb. K_2O to legumes ...	107.2	6.7	54.5	8.4	106.2	9.9	124.4	9.3
E. B+pot. sulph. 80 lb. K_2O to legumes ...	87.8	5.1	61.4	9.5	108.9	8.4	106.2	6.9
F. No manure ...	104.7	5.5	76.6	8.5	89.1	7.7	110.3	7.3
Critical difference (5%)	35.72	1.5	37.8	3.4	30.8	3.0	35.2	2.0

From the yields of maize fodder, it will be seen that there is practically no difference between the after-effects of phosphate manured legumes and direct manuring of maize. But the wheat yields definitely show that the direct manuring of the crop had significant effect over the after-effects of phosphate manured legumes.

(c) N. P. K and Ca fertilizers

(i) *Effect of N. P. K and Ca fertilizers on wheat.*—This experiment was continued on the same lines as reported last year. The design is a 34 quasialatin square with two replications, partially confounding the 3-factor interactions. Nitrogen was applied in the form of am. sulphate at 0, 20 and 40 lbs. nitrogen per acre. Superphosphate was applied to supply 0, 80 and 160 lbs. P_2O_5 per acre; sulphate of potash was applied to supply 0, 80 and 160 lbs. K_2O and lime at 0, 5 and 10 mds. per acre. Wheat C, 518 was grown as test crop after a *kharif* fallow. Unlike previous years' results, increasing doses of nitrogen gave higher yields which were significant. Other main effects or interactions were not significant.

(d) Green manuring experiments

The experiments conducted during the year under reports were mostly confined to the study of the after-effects of green manuring done in 1946-47. In experiment to see the value of green manuring when the green manuring crop of sannhemp was (i) grown *in situ* and buried, (ii) grown in another field and buried in the experimental plots and (iii) grown in another field and buried in the experimental plots after composting, the best yields of maize and wheat were obtained from plots which were treated by the first method. This shows the value of green manuring with a legume grown *in situ*.

In experiment with indigo for green manuring, the after-effects were marked on the following crops of maize and wheat. These results indicate that the effect of green manuring lasts for more than one season under conditions prevailing here.

(i) *Green manuring experiment with cowpeas in combination with different fertilizers.*—In this experiment the green manuring crop was buried with different fertili-

zers to hasten decomposition. Wheat C. 228 was grown in the *rabi* season to test the effect of green manure treated with fertilizers. The results are tabulated below :—

TABLE XV.

Yield of wheat C.228 grain in maunds per acre.

	Treatment per acre.	Wheat 1947-48
A.	Green manure alone	15.2
B.	Green manure+Am. sulph. 40 lb. N	16.9
C.	Green manure+super 80 lb. P_2O_5	14.3
D.	Green manure+Lime 1 ton	16.3
E.	Green manure+Am. sulph. 40 lb. N+Lime 1 ton	17.2
F.	Green manure+Super 80 lb. P_2O_5 +Lime 1 ton	12.9
G.	Green manure+Am. Sulph. 40 lb. N+Super 80 lb. P_2O_5	17.9
H.	Green manure+Am. Sulph. 40 lb. N+Super 80 lb. P_2O_5 +Lime 1 ton	19.8
I.	Green manure+Bonemeal 80 lb. P_2O_5	18.9
J.	Green manure+Bonemeal 80 lb. P_2O_5 +Sulphur 166 lb.	15.0
	Critical difference (5%)	7.09

The differences among the treatments are not significant. Treatment H, however, gave the highest yield of wheat.

(ii) *Green manuring experiment with sannhemp grown in situ and brought from outside.*—This experiment was started in 1945-46 at the instance of the then Department of Agriculture, Government of India to see whether sannhemp grown in another field, such as in waste land on either side of the railway line and incorporated in the cultivator's field direct or after composting would prove as effective for green manuring purposes as that grown *in situ*. The green manuring operations were carried out in *kharif* 1946 after which wheat was grown in *rabi* 1946-47. During the year under report maize and wheat were grown to see the after effects. The results are given below.

TABLE XVI.

Yield of maize No. 2 and wheat C.518 grain in maunds per acre.

Subplot treatment per acre.		Main-plot treat per acre.									
		No G.M. Maize Wheat		Sannhemp grown in		Sannhemp from outside		Sannhemp from outside		Average. composted.	
				situ.		at 200 mds.		@ 200 md. &			
				Maize	Wheat	Maize	Wheat	Maize	Wheat		
No manure	...	3.6	6.5	9.7	7.8	7.8	4.5	4.5	4.2	6.4	5.8
Am. sulph 40 lb N	...	5.6	4.5	8.0	7.7	6.4	7.3	7.0	6.1	6.8	6.4
Super 80 lb P ₂ O ₅	...	4.2	4.5	6.5	8.7	4.1	7.0	4.5	9.0	4.8	7.3
Am. sulph 40 lb N	...	...	...	...	...	...	...	...	...	...	...
+super 80 lb P ₂ O ₅	...	4.8	6.5	7.5	5.8	5.6	5.9	4.1	4.1	5.5	5.6
Average	...	4.6	5.5	7.9	7.5	6.0	6.2	5.0	5.9	...	...
Critical difference (5%)		for mainplot treatments						Maize		Wheat	
"		" Subplot "						3.86		0.94	
"		" treatment combinations						1.77		0.58	
"		"						3.54		1.17	

The yields of maize and wheat were poor after a heavy crop of wheat taken in *rabi* 1946-47. As regards the after-effects of the mainplot treatments, sannhemp grown *in situ* has given significant results. The sub-plot treatments, in general, are not significant.

(iii) *Green manuring experiment with indigo*.—Last year results were given on the effect of green manuring with indigo on the yield of wheat. During 1947-48, maize and wheat were grown to study the after effects of green manuring. Indigo was grown in 1946 with P, Ca, PK, PCa and PKCa in combination with and without nitrogen. The results obtained with wheat in 1946-47 showed that the effect of green manuring was alone significant over no green manuring. Results obtained during the year under report are given in the following table.

TABLE XVII.

Yield of maize No. 2 green fodder and wheat C.518 grain in maunds per acre.

Treatments	Maize 1947	Wheat 1947-48
Green Manure with indigo ...	251.9	18.3
No green manure ...	195.4	16.3
Critical difference (5%) ...	58.79	9.73
Nitrogen ...	223.2	18.1
No nitrogen ...	224.1	16.4
Critical difference (5%) ...	23.09	5.29
No manure ...	220.5	18.0
P ...	226.1	14.8
Ca ...	214.7	17.1
PCa ...	229.0	18.7
PK ...	220.6	18.2
PKCa ...	235.7	16.7
Critical difference (5%) ...	21.57	3.81

* Note: 40 lb N as am. sulph., P as super 4 mds., K as pot. sulph. 4 mds. Ca as lime 10 mds., per acre

From the above results, it will be seen that the after-effects of green manuring with indigo is marked on maize and wheat, but the differences are not significant.

(iv) *Fertility building experiment with bhusa*.—This experiment was started with the object of testing the manurial value of *bhusa* when ploughed down in combination with different fertilizers. Wheat C.518 was grown as test crop in *rabi* 1947-48. *Bhusa* was buried in July 1947 with the break of the monsoon.

TABLE XVIII.

Yield of wheat C.518 grain in maunds per acre.

Treatment per acre.	Wheat 1947-48
A. No bhusa ...	15.0
B. Bhusa 60 mds., alone ...	13.3
C. " + Super 80 lb P_2O_5 ...	10.2
D. " + " " + Am. sulph 40 lb N. ...	14.7
E. " + " " + pot. sulph 40 lb K_2O ...	18.9
F. " + " " + pot. sulph 40 lb K_2O ...	12.3
Critical difference (5%) ...	4.72

Among the treatments with *bhusa*, the combination of *bhusa* and NPK or NP gave better results than *bhusa* without nitrogenous fertilizers which is according to the expectation.

(c) Placement of fertilizers

These experiments were started last year with a view to studying the effect of fertilizer when placed near the seed as against the method of broadcasting. There is also a considerable economy when fertilizers are placed near the seed, as plants are able to utilize the fertilizer more effectively than when they are broadcast. In experiment on berseem, high yields were obtained by placement of fertilizers when the crop was sown in rows 6 inches and one foot apart.

(i) *Fertilizer placement experiment on berseem*.—This experiment was started in 1947-48 to study the effect of broadcast and placed fertilizers on berseem. For placement of fertilizers, berseem was sown in rows 6" and 1 foot apart and the fertilizers were drilled below the depth at which the seeds were sown. The results were as follows :—

TABLE XIX.

Yield of green berseem in maunds per acre.

Subplot treatments.				Mainplot treatments.			Average
			Sown and manured broadcast	'Sown 1' part & fertilizers placed.	Sown 6" apart and fertilizers placed.		
No manure	...	...	351.6	342.7	361.4		352.0
Super 80 lb P_2O_5	...	...	441.3	469.5	440.2		450.4
" " + pot.							
sulp 60 lb K_2O	...	...	417.4	479.6	493.7		463.7
Super 80 lb P_2O_5 +							
am. sulp 40 lb N.	...	...	442.8	467.6	498.4		469.7
" " +							
pot. sulp 60 lb K_2O	...	...	509.8	520.9	573.7		534.9
Average	...	...	432.6	456.1	473.5		
Critical difference (5%)	for mainplot treatments	...	...	...	...	56.42	
" " "	" Subplot	"	...	...	...	22.14	
" " "	" treatment combinations	"	...	...	...	98.61	

From the above results, it will be seen that when berseem was sown in rows and fertilizers placed, the crop gave more yields than when berseem was sown and manured broadcast, but the differences in yields were not significant. In the case of fertilizer treatments, NPK gave significantly more yield than the other treatments. The treatment NP, PK and P also showed significantly more yields than the control.

B.—EXPERIMENTS ON MIXED CROPPING

(i) *Effect of fertilizers on mixed crops*.—This experiment was started last year to study the response of peas-barley and gram-wheat mixtures to fertilizer treatments. The results obtained with the wheat-gram mixture are given below. In the case of barley-peas mixture, the results were not significant.

TABLE XX.

Yield of wheat C.518 and gram N.P.58 mixture in maunds per acre.

Treatment per acre						Wheat-gram 1947-48	
A.	No. manure	...	...	...	...	...	11.2
B.	Am. sulph. 40 lb N.	...	...	...	...	...	19.4
C.	Super 60 lb P_2O_5	...	...	...	...	...	15.5
D.	Am. sulph 40 lb N + Super 60 lb P_2O_5	...	...	...	...	...	26.3
E.	Super 60 lb P_2O_5 + pot. sulph. 60 lb K_2O	...	...	...	...	...	15.2
F.	" + " + " + Am. sulph. 40 lb N.	...	...	...	...	...	18.0
Critical difference (5%)						...	6.33

The treatment NP gave significant difference over all other treatments. Nitrogen and NPK treatments also showed superiority over the control.

C.—CULTURAL EXPERIMENTS

A few cultural experiments were started during the year under report. In one experiment, the effect of spacing, dates of sowing and depth of sowing was studied on the yield and incidence of wilt in gram. The results showed that late sowing, narrow spacing and shallow sowing were conducive to high yield. The incidence of wilt was less in late and shallow sown plots.

The method of ploughless cultivation and ensymic manuring given out by Mr. G. P. Pillai was tested against normal cultivation and manuring on wheat and it was found that the latter method was superior to the former method.

(i) *Cultural experiment for the control of gram wilt.*—It was started in 1947-48 to test the effects of spacing, depth of sowing and different dates of sowing on the yield and incidence of wilt in gram. The results were as follows :—

TABLE XXI.

Yield of gram N.P.58 in maunds per acre and mortality per cent. due to wilt in parentheses.

Depth of sowing			Sown on			Sown on			Sown on			Average.
			27.10.47			10.11.47			24.11.47.			
			Rows	Rows	Rows	Rows	Rows	Rows	Rows	Rows	Rows	
			10"	15"	20"	10"	15"	20"	10"	15"	20"	
2½ inches	...	...	17.1	17.0	22.9	23.3	22.3	21.4	22.2	21.3	16.6	20.1
												(13.11)
5 inches	...	...	15.7	14.3	21.8	17.3	17.2	19.2	23.2	23.1	13.8	17.0
												(7.52)
Average (Sowing dates)			27.10.47; 17.2; 10.11.47:			19.3; 24.11.47:			19.4			
			(10.83)			(12.38)			(7.73)			
Average (spacing)			10": 19.3 ; 15"			: 18.6 ; 20" :			17.8			
			(11.24)			(9.27)			(10.43)			
Critical difference (5%) for dates of sowing									...			7.29
" " " " spacing									...			6.40
" " " " depth of sowing									...			2.38
" " " " treatment combinations									...			9.33

The above results indicate that shallow sowing is significantly superior to deep sowing while mortality due to wilt is also more in deep sown plots than that recorded in shallow sown plots. Other differences in yields due to spacing and dates of sowing are not significant. There is however, indication to show that late sowing and narrow spacing are both conducive to high yields.

Further, in late sown plots mortality due to wilt has been small.

(ii) *Ploughless cultivation and enzymic manuring*.—Mr. G. P. Pillai of Science Bureau for Rural India, Calcutta, claims that any crop, field or vegetable, can be grown to give high yields without ploughing the land and by the application of his enzymic manure which affords adequate nutrition for the growing plants. Mr. Pillai further claims that one gram of his enzymic manure contains two thousand million active bacteria, six ozs of which is sufficient to fertilize one acre of land. The enzymic bacteria carry to the root hairs of plants their enzymes which plants readily absorb into their system.

Six oz. of enzymic manure was mixed with 100 gallons of water and then sprayed with a hand sprayer once before sowing and again in March. The plots were not cultivated; weeds were removed by *khurpi* before sowing and seeds sown with the help of a hand plough and covered with *khurpi*.

In the control plots, normal bullock cultivations were given. Manures in the form of mustard cake at 10 mds., am. sulphate at 10 lb. N. superphosphate at 40 lb. P_2O_5 and sulphate of potash at 40 lb. K_2O per acre were applied before sowing. Wheat C.518 was sown with a drill. The results given in Table XXII.

TABLE XXII.

Yield of wheat C.518 in maunds per acre.

Treatments	Wheat 1947-48					
A. Ploughless cultivation and enzymic manuring	...	...	...	...	...	14.8
B. Control	...	...	...	...	...	20.6
Critical difference (5%)	...	...	...	...	...	5.64

The control gave significantly more yield than the treatment of ploughless cultivation and enzymic manuring.

D.—FLOOD WATER FARMING

(i) *Flood water farming experiment*.—These experiments were started in 1941-42, to study the effect of flooding the field in July, August and September to make up the deficiency of the monsoon rainfall, on the yield of wheat, barley, gram and toria, as compared to yields under *barani* (rainfed) conditions. These experiments have shown that in the years when the monsoon rainfall is low, flooding with surplus river water ensures crop yields in *barani* tracts. The results obtained during the year under report are tabulated below :—

TABLE XXIII.

Yield of wheat, barley and toria in maunds per acre.

Crop		Flooded or Rainfed.	No manure	Am. sulp. 40 lb N.	Am. sulp. 40 lb N.	Average.
Wheat N. P.4	...	Flooded	23.6	22.2	25.0	23.6
		Rainfed	8.1	7.1	7.5	7.6
Wheat „ 13	...	Flooded	24.2	22.5	24.3	23.6
		Rainfed	8.6	5.4	6.0	6.7
Toria (local)	...	Flooded	16.3	15.6	16.7	16.2
		Rainfed	7.7	5.6	7.9	7.1

In all the crops reported above, it will be seen that yields recorded from the floods series are considerably more than those got from the rainfed series. Yields of gram are not reported owing to some discrepancies.

E.—CULTIVATORS' HOLDINGS

(i) *Old holdings*.—The three old holdings on which different intensities of green manuring are being followed were continued. The yields obtained from these holdings are given below :—

TABLE XXIV.

Yield of crops in maunds.

Crops.		Holding with 66.6 percent intensity of green manure.			Holding with 50% intensity of green manure.			Holding without green manuring.		
		Total area (ac)	Total yield	Yield per ac.	Total area (ac)	Total yield	Yield per ac.	Total area (ac)	Total yield	Yield per ac.
Maize grain	...	1.0	15.2	15.2	2.0	18.4	9.2	2.0	28.0	14.0
Wheat grain	...	4.0	106.9	26.7	3.0	69.2	23.1	1.0	22.0	22.0
Barley grain	...	1.0	31.3	31.3	1.0	33.9	33.9	2.0	31.8	15.9
Peas grain	...	1.5	25.8	17.2	3.0	45.3	15.1	3.0	33.4	11.1
Oats grain	...	...	...	...	...	...	...	1.0	24.3	24.3
Jowar green fodder	...	1.5	436.3	290.9	2.0	603.1	301.6	2.0	534.9	267.5
Cowpeas	„	...	...	...	...	...	...	2.0	319.5	159.8
Berseem	„	1.0	588.8	588.8	1.0	456.3	456.3	1.0	675.0	675.0

From the above results, it is evident that the holding green manured with 66.6% intensity, has in general given better yields than the other holdings. The holding with no green manuring has given comparatively poorer yields.

(ii) *New holdings*.—Four new holdings, each 6 acres, have been started during the year under report incorporating legumes manured with phosphate which would build up soil fertility more quickly than the cultivators' usual rotation systems in which phosphate is excluded. Out of four holdings, three are irrigated and one is rainfed. It is proposed to deal with the results after the accumulation of data for at least three years.

F.—VARIETAL TRIAL

(i) *Berseem varietal trial*.—Four varieties of berseem, viz. (a) Delhi (acclimatized Peshawar seed), (b) 10C (Botany Division Selection), (c) Miscawi (Egyptian), (d) Fahli (Egyptian) were tested for fodder and seed yields. The results are given below :—

TABLE XXV.

Yield of berseem green fodder and seed in maunds per acre.

			Delhi	10C	Miscawi	Fahli	Critical difference (5%)
Berseem green fodder	...	...	532.3	506.4	536.8	556.0	49.92
Berseem seed	...	...	1.4	0.5	1.3	1.3	0.4

As regards fodder yields, there is no significant differences among the varieties. The yield of seed shows that there are no significant differences among Delhi, Miscawi and Fahli, but all of them are superior to variety 10C.

G.—GRASSES AND LEGUMES FOR FODDER AND PASTURAGE

1. *Collection of grasses*.—The collection of grasses from the various parts of India and also from other countries which has been in progress since 1942 was continued. The collection represents 32 indigenous and eight exotic species with some of their available strains. Out of these 15 indigenous species have been selected for detailed agronomic work which will be started next year.

2. *Collection of legumes*.—Sample seeds of 24 varieties of soyabean were received from the U.S.A. through the courtesy of the American Embassy in New Delhi. Successional sowings of these varieties are in progress to determine the best time to sow each of these varieties. In general, all of them appear to be suitable for the *kharif* sowing.

There are eight exotic and indigenous legumes under trial which appear suitable for fodder purposes.

3. *Ley-farming, or alteranate husbandry*.—The first phase of the experiment, *viz.*, the effect of different fertilizers on the yield and quality of Rhodes grass-lucerne mixture, has been in progress since 1945. During the year under report, four cuttings of the fodder were taken—the bulk in the first two cuttings was contributed by Rhodes grass, while lucerne predominated in the other two cuttings.

The second phase of the experiment, *i.e.*, the effect of the 3-year's ley on the soil fertility, as judged from the yield of subsequent maize and wheat crops, will be undertaken next year.

The results obtained during 1947-48 and the total fodder yields since 1945 are given in Table XXVI.

TABLE XXVI.

Yield of green fodder in maunds per acre.

Treatment per acre.	1947-48		
	Total of 1st and 2nd cuttings; Rhodes grass predominant.	Total of 3rd and 4th cuttings; lucerne predominant.	Total of 10 cuttings since 1945.
A. No manure	126.7	78.5	767.8
B. Am. sulph. 80 lb N.	175.5	54.4	936.4
C. Super 80 lb P ₂ O ₅	217.0	145.4	1093.1
D. Pot. sulph. 80 lb K ₂ O	144.6	43.7	685.6
E. Bonemeal (burnt) 80 lb P ₂ O ₅	111.0	59.0	644.0
F. B + C (NP)	261.1	106.7	1329.0
G. B + C + (NPK)	267.1	108.8	1322.2
H. B + E (NP)	187.7	52.6	928.5
I. B + E + D (NPK)	184.9	63.5	973.1
J. Am.phosphate 80 lb N.	258.2	99.8	1298.8
Critical difference (5%)	68.6	33.3	192.7

The results of first and second cuttings show that significantly high yields have been obtained with P₂O₅ as superphosphate alone or in combination with nitrogen. Bonemeal has again shown negative results. The analyses of third and fourth cuttings show that only superphosphate is significant over the control.

The total yields from 10 cuttings show superiority of NP, NPK, and am. phosphate treatments over all other treatments. Potash and bonemeal have given negative results.

II.—CATTLE BREEDING AND MANAGEMENT

SAHIWAL HERD

1. Herd Strength

On 1st July, 1947, the herd strength was 287 head, and on 30th July, 1948 it was 321. Due to difficulty in the disposal of male stock for breeding purposes for the last few years, the herd strength has steadily increased above 300 head.

2. Health and condition

The general condition of the herd remained good throughout the year. The herd was free from the attacks of foot and mouth disease as well as other contagious diseases. There was a high percentage (22.3%) of mortality among calves due to navel ill, caused by direct infection through the navel. The prophylactic measure of injecting calves immediately after birth with their dam's serum controlled mortality in most of the infected cases. There were sporadic cases of Johnes' disease in the herd with a few mortality in cows.

Cattle were protected against Haemorrhagic Septicæmia, Black Quarter and Rinderpest.

3. Milk yield

On an average 106 milch cows were maintained in the herd, out of which 74 cows were in milk and the rest dry. The percentage of cows in milk was thus 70. There was a fall in milk yield during the year under report. The wet and overall average per cow per day were 19.5 lb. and 13.7 lb. respectively as against 20.9 lb. and 15.1 lb. recorded in the previous year. The drop in yield was conspicuous from September, 1947, owing to irregularity in the supply of feeding stuff caused by disturbances prevailing in Delhi at that time. The supply was regularised towards the end of the year and this had good effect on the yield.

Of 91 cows and heifers who completed their lactations during the year, 14.2 per cent. yielded below 4,000 lbs., 11.00 per cent. between 4,000 and 5,000 lbs., 12.1 per cent. between 5,000 and 6,000 lbs., 33.0 per cent. between 6,000 and 7,000 lbs., 19.8 per cent. between 7,000 and 8,000 lbs. and 9.9 per cent. above 8,000 lbs.

4. Early maturity treatment

The average production capacity of 26 early maturity heifers, who were mated before two years' age with alive weight of 600 lbs. and above, was 5,139.3 lbs. in 287 days, whereas that of seven heifers who were mated over two years' age, was 5,684.4 lbs. in 283 days.

5. Record of stud bulls

On an average, 12 stud bulls were maintained for breeding purposes. Five young bulls from very high yielding dams were taken in for progeny testing. The stud bulls Mohan and Nanda gave some very promising progeny with strong constitution. The average production capacity of the daughters of Mohan was 5,502 lbs. and that of Nanda 6,976 lbs. The bull indices for Mohan and Nanda worked out to 5,023 and 6,393 respectively.

6. Calf Rearing

All calves were weaned at birth and reared on standardised milk containing 3.5 butter-fat. Out of 101 calves born alive, 80 were reared. Excluding the deaths due to abortion, congenital deformity and transmission experiments carried out by the staff of the I. V. R. I. on naval ill, the percentage mortality among the pailfed calves, below the age of 3 months were 14.6. Out of 103 calves born, 52.4 per cent. were females and 47.6 per cent. males. The average birth weight of female calves was 49.9 lbs. and that of male calves 53.7 lbs. The daily rate of growth for males was 1.27 lbs. and that for females was 1.16 lbs. which are considered to be satisfactory.

7. Premilking and four times milking

Due to irregularities in the supply of feeding stuff, the down calves which were in poor state of health, could not be subjected to premilking treatment. These cows after calving failed to come in heavy flush and thus affected the yield. Many of the freshened cows and heifers which were not found fit to undergo the strain of fourtimes milking had to be put under reduced number of milkings. About 27 per cent. of cows in milk were under reduced number of milkings. The rest of them were milked four times a day.

8. All-India Cattle Show

Seventeen cattle were exhibited at the Seventh All-India Cattle Show which was held in Delhi in February, 1948. The positions secured by the Institute Cattle are shown below:—

Class.	Name	Position secured.
Bull	Lala	II
Cow	Ancham	II
Cow	Dereng	III
Young cow	Pradha	I
Heifers over 2 years	No. 81	I
Heifers below 2 years	No. 114	I
Heifers ,, ,,	No. 107	II

A few of the best specimens of stud bulls exhibited from the Sahiwal herd were rejected, being off colour. Cattle of red colour alone were accepted, whereas for the registration of Sahiwals in the Indian Herd Book, all colours, except white are accepted.

III Agricultural Research Sub-Station, Karnal

AGRONOMY

I. SEASONS AND CROPS

The season was marked by an unusually defective distribution of rainfall during the *Khariff* and *Rabi* seasons. The total precipitation received within the period May to October was 30.6 inches of which 24.7 inches were received in September. In the *Rabi* season 6.39 inches was received in February out of 9.33 inches of rainfall from October to April. (Table I).

TABLE I.

Meteorological data for the crop year 1947-48.

Month		Mean Max. Temperature °F		Mean Min. Temperature °F		Relative Humidity % 7.0 hours	Rainfall inches.	No. of on days.
July,	1947	...	...	103.4	79.7	70	1.22	3
August,	1947	...	...	98.9	75.8	76	4.02	9
September,	1947	...	...	86.3	73.2	91	24.70	13
October,	1947	...	...	85.2	62.4	76	...	...
November	1947	...	...	80.9	51.4	71	...	...
December,	1947	...	...	69.4	44.2	76	0.24	1
January,	1948	...	...	67.1	42.7	82	0.97	1
February,	1948	...	...	72.1	47.2	83	6.39	4
March,	1948	...	...	78.8	54.3	63	1.73	5
April,	1948	...	...	100.9	66.8	50	...	...
May,	1948	...	...	106.7	74.3	45	0.25	2
June,	1948	...	...	107.1	81.2	48	1.11	3
Total						-	40.62	41

Rains in September damaged the standing *Khariff* crops for water logging was extensive. Seed setting of *Jowar*, *Bajra*, Maize, soyabeans, cowpeas and other *Khariff* pulses was extremely poor. High winds accompanied by rain caused extensive lodging in rice crop. *Rabi* pulses, *i.e.*, gram and peas suffered from stagnation of water in low lying areas. Redeeming feature of the seasons was that preparatory tillage of *Rabi* crops could be finished in time and weather conditions during April and May were favourable for threshing these crops. Mean maximum temperatures were rather low from December

to March which arrested full development of oats, wheat and barley crops. Tillering was thus affected and yields were low. Conditions of drought prevailed in the period April to June which placed restriction on cultivation of early fodder crops.

II. INSECT PESTS AND DISEASES

Field cricket (*Gyrillus* Sp.) was active in May and June. Grass hoppers (*Crotoge-nous* sp) together with field crickets did considerable damage to germinating cotton. Pink-bell worm (*Erias falma*) was active from September to November. The grass hoppers did extensive injury to the young plants of *Jowar*. *Crotogonus* sp. was again active in September and early part of October. Incidence of *Gandi* bug of paddy was the highest on N.P. 137; less so on N.P. 125 and 130 and least on N.P. 97. The last mentioned type escaped damage because of its earliness. The incidence of *Chilo Zonellus* (top shoot borer) was not disproportionately high except in very early sown maize crop. Gram pod borer did some damage to the pods but the incidence was rather low. Aphids made their appearance on winter cereals late in March. The extent of damage was small. *Pyrilla* sp. did not cause extensive depredation on sugarcane crop.

Wilting of cowpeas plants was noticed in patches. A few plants of cotton suffered from wilt. The wilt infection on gram was rather mild. Orange and black rusts appeared on wheat to a small extent. Also Karnal bunt infection was low.

III. AGRONOMICAL EXPERIMENTS

A.—GENERAL REMARKS.

The experimental results were vitiated largely due to weather factors and uncontrollable depredations of refugees, from the adjacent refugee camps, on the standing crops of maize, *Bajra*, *Jowar*, paddy, cowpeas, *khariff* pulses, etc. In September, heavy rains (24.7 inches) caused water logging which brought about physiological wilting and death of the standing crop. In consequence, the yields were appreciably reduced. The extent of reduction was as high as 75 per cent. in grain and fodder yield. Downpour of 5.3 inches on 21st and 1.5 inches of rainfall on 22nd and 23rd February, 1948 again caused stagnation of water in the fields. In consequence, gram and peas crops in several cases were totally destroyed. Sugarcane was the only crop which suffered the least from seasonal effects.

B.—DETAILED RESULTS.

I. Manurial and cultural experiments

The results of various experiments on the manuring of paddy, berseem and winter legumes, wheat maize, etc., have been summarised. They include experiments on direct nitrogenous, phosphate, potash and green manuring and indirect manuring through legumes. On wheat tillage-cum-manurial experiments have also been reported.

(a) Experiments on paddy.

Manurial experiments on paddy carried out at Karnal are (i) N.P.K. Series (ii) Bonemeal in combination with farm yard manure and ammonium sulphate (iii) direct and indirect manuring of paddy in different paddy-winter legumes rotations and (iv) paddy seedling dipping experiment.

(i) The results of the *N.P.K. series* are given in Table II below :—

TABLE II.

Paddy (N.P. 125) yield in mds. P.A.

N-Ammonium sulphate. P_2O_5 -Super phosphate : K_2O -Potassium sulphate.

N	Treatments in Lbs. per acre.		Direct manuring of paddy. Previous crop	
	P_2O_5	K_2O	Fallow	Wheat.
	Nil		18.5	17.1
40	...	...	23.6	21.3
...	40	...	18.7	19.8
...	...	60	16.7	18.5
40	40	...	23.0	19.6
40	...	60	24.1	20.7
...	40	60	19.0	23.4
40	40	60	23.9	19.2
General mean			20.9	18.65
C.D. at 5%			4.8	6.1

The yield of paddy in the paddy-fallow rotation was increased by the application of nitrogen alone or in combination of phosphate and Potash. The two latter treatments were not effective in augmenting the yield. The differences in yield of paddy due to manurial treatments were not significant in the experiment with paddy wheat rotation.

(ii) Application of bone meal alone at two levels of 80 and 120 lbs. phosphate and in combination with farm yard manure or ammonium sulphate applied at the rate of 40 lbs. nitrogen did not enhance the yield of paddy either when they were applied direct to paddy or to the berseem crop preceding paddy.

(iii) The results of the manurial experiments on paddy-legume rotations are given as under (Table III) :—

TABLE III.

Paddy (N.P. 125) yields in mds. per acre.

N-40 lbs. N as A/S P_2O_5 80 lbs. P_2O_5 as super K-120 lbs. K_2O as S/Bot.

Preceding legume crop	To legumes		P	To paddy				P	N	General Mean	S. E.
	N.	P. K.		No manure	N	P.	K.	PK			
Berseem	...	24.8	27.7	23.6	26.3	27.0	25.1	25.9	25.7	25.8	+2.0
Shaftal	...	34.4	32.4	33.2	34.7	33.6	31.0	35.6	32.7	33.5	+1.9
Senji	...	22.7	21.7	22.1	27.0	23.2	26.1	24.5	25.9	24.2	+3.4
Methra.	...	27.4	25.4	22.9	26.2	25.0	24.7	26.4	28.7	25.9	+2.8
Peas.	...	17.6	14.9	19.9	19.8	19.3	17.3	22.0	18.4	18.7	+1.7
Gram	...	28.4	25.5	26.3	25.0	25.3	24.8	24.0	26.6	25.7	+2.0

Yields of paddy after shaftal were the highest and after peas the lowest per acre. After Berseem, *Senji*, *Methra* and gram the out-turns of paddy irrespective of manurial treatments were almost the same.

The differential manuring of legumes for residual response in yield of paddy and manuring of paddy directly did not indicate significant differences amongst the various treatments.

(iv) For the third season *pre-treatment of paddy seedlings* in suspensions of (a) equal parts night soil, wood ashes and ordinary soil; (b) equal parts of farm yard manure, wood ashes and ordinary soil; (c) a solution of 10% ammonium nitrate, 10% super phosphate (triple) and 10% potassium sulphate as against (d) Control did not result in higher out turn of paddy crop.

(b) *Experiments on berseem and other winter legumes.*

(i) An *N.P.K.* experiment on maize berseem rotation indicated the results as given in (Table IV) below :—

TABLE IV.

*Yield of Berseem Fodder.*N as ammonium sulphate P_2O_5 as super K_2O as Potassium sulphate.

Treatments per acre.			Berseem Fodder		(b) 4 C.H.	Remarks.
N	P_2O_5	K_2O	Mds. per Acre.	(a) 5 E. S.H.		
A.	...	No manure.	...	530.0	416.0	
B.	...	120	...	729.1	642.3	
C.	40	120	...	125.0	659.6	The experimental area being small, there are only two replications of the experiment in each case.
D.	...	120	160	...	721.5	
E.	40	120	160	...	156.0	
General Mean			...	692.2	606.8	
C.D. at 5 %			...	161.4	98.9	

Berseem yield was not affected by nitrogenous manuring but super-phosphate application significantly increased the yield of the fodder crop. There was no response to potash dressing except to a very small extent when it was applied in combination with nitrogen and phosphate.

(ii) In another experiment, where comparison of different legumes is in hand, the results obtained were (Table V) :—

TABLE V.

*Yield of legumes in mds. per acre.*N as ammonium sulphate P_2O_5 as super; K_2O as Potassium Sulphate.

Treatments in lbs. per acre							Berseem	Shaftal	Methra	Peas
N	P ₂ O ₅		K ₂ O							
A.	40	plus	80	plus	120	to legume only	470.2	435.5	13.0	6.7
B.	Nil	„	80	„	120	Do	520.5	411.8	8.8	5.7
C.	Nil	„	80	„	Nil	Do	529.9	395.9	9.4	5.5
D.	40	„	80	„	120	to paddy only	440.7	352.9	14.6	5.4
E.	Nil	„	80	„	120	Do	421.8	342.8	10.2	5.1
F.	Nil	„	80	„	Nil	Do	485.18	323.4	15.4	5.8
G.	40	„	Nil	„	Nil	Do	235.67	377.7	22.7	5.9
H.	No manure to each crop.						285.3	404.0	11.59	4.70
	Critical difference (5% level.)						97.84	80.86	11.82	2.67

Significant differences amongst the treatments were shown by berseem crop only. Application of Super-Phosphate indicated increase in yield of berseem. This is evident from a comparison of treatments G. & H. as against A, B, C, D, E & F. Slightly better response was realised by direct application of Phosphate to berseem than the residual effect from paddy. Nitrogen and Potash proved ineffective.

(iii) *Effect of different doses of Super-phosphate on berseem after paddy* was studied in another experiment. The results are summarised in (Table VI).

TABLE VI.

Fodder outturn in mds. per acre.

lbs. P_2O_5 applied as Superphosphate per acre				G.M.	S.E.	Critical differences at $P=0.05$
40	120	160	200			
398.7	497.6	566.8	547.0	502.52	+50.25	160.76

It is evident from the results that the yield of berseem progressively increased up to 160 lbs. P_2O_5 per acre. The yield difference between 40 lbs. to 160 lbs. treatments was significant. These results confirm the previous findings that maximum returns of berseem fodder are shown by 160 lbs. P_2O_5 dose of super per acre.

(c) *Experiments on wheat.*

(i) *A green manuring cum N.P.K. experiment*, was conducted on wheat. The summarised results are presented (Table VII) as under :—

TABLE VII.

Mean yield of wheat Mds. per acre.

N as ammonium sulphate P_2O_5 as Super phosphate: K_2O as Potassium Sulphate.

Particulars of Top Dressing Treatments			Green manure crops inverted				in Khariff.	General
N	P_2O_5	K_2O	No	Guar	sann	Cowpeas	Meth	
	Nil		G.M.		hemp			Mean.
40	...	...	13.50	19.70	18.49	17.39	17.76	17.37
...	...	...	18.12	17.15	17.83	18.00	21.00	18.46
...	...	80	13.50	15.20	17.27	20.92	14.72	16.32
40	...	80	17.15	18.49	19.46	20.07	19.09	18.85
...	80	...	16.54	16.42	18.36	15.32	15.20	16.37
40	80	...	17.63	17.88	20.19	18.97	20.19	18.97
...	80	80	13.13	16.42	18.97	17.03	16.05	16.32
40	80	80	15.45	20.19	18.36	19.46	18.24	18.34
General Mean			15.63	17.68	18.59	18.39	17.83	17.63
Critical difference (5% level)					7.22			1.99

The wheat out-turn following different green manure crops did not exhibit significant differences amongst themselves. With respect to mean yields sann hemp and cowpeas appeared better green manure crops than *Guar* or *meth*.

The effect of nitrogen in improving the yield of wheat crop was evident from the experiment. The outturns per acre for K, P, or PK were significantly lower than N, NK, NP or NPK treatments.

(ii) The object of the *fertilizercum tillage experiment* is to study the effect of deep tillage in fallow period on the yield of wheat and to examine the response indicated by

TABLE VIII.
Mean yields in mds. per acre.

To dressing Treatments.	Cultivation treatments.			General Mean.
	Country ploughing	Victory ploughing	Tractor ploughing	
A. Nil.	6.72	8.00	8.44	7.72
B. 60 lb. N of sulphate of ammonium ...	5.63	7.19	8.44	7.08
C. 60 lbs. N as f.y.m.	7.25	8.44	10.75	8.81
D. 40 lb. N as f.y.m. plus 40 lbs. N at ammonium sulphate. ...	10.16	11.00	11.56	10.91
General Mean	7.44	8.66	9.80	8.63

ammonium sulphate compared to farm yard manure as against no manure treatment. The experiment indicated that deep fallow ploughing improves the yield of wheat crop. Application of a dose of 80 lbs. of nitrogen, half as f.y.m. and half as ammonium sulphate exhibited significantly higher yield than no manure and an application of 60 lbs. N as sulphate of ammonium per acre. The experiment is being continued.

(iii) In the second *fertilizercum tillage* experiment instead of fallow cultivation the land was green manured with sann hemp during the monsoon and was tilled with tractor implements or victory *plus* country plough prior to sowing of wheat crop. Phosphate and Potash were applied to the green manure crop at sowing time and nitrogen was top dressed to wheat at seeding. The results of the experiment are detailed below (Table IX).

TABLE IX.
Mean yields in mds. per acre.

Manurial lbs. applied to Sann hemp G.M.		Treatments per acre. wheat.		Tractor implements culti- vation.	Victory cum country plough cultivation.
P ₂ O ₅	K ₂ O	N	...		
Nil	Nil	Nil	...	7.01	8.78
Nil	...	60	...	10.69	9.11
80	...	60	...	9.30	11.03
80	120	60	...	10.80	9.64
General Mean				9.45	9.64
Critical difference (5% level)				2.05	3.81

In both cases application of nitrogen improved the out turn per acre of the crop. The differences were significant in the case of tractor cultivated plots.

(iv) A preliminary comparison of applying super-phosphate to green manure (sann hemp) and top-dressing to wheat in another experiment was conducted in the season under report. The results indicated that superior response in yield is indicated by application of phosphate to green manure crop. A regular experiment is being laid out next year.

(d) *Experiments on maize.*

Residual response of the application of fertilizers to berseem was studied in two of the experiments. The responses shown were as under :—

TABLE X.

Out-turn of Maize grain in mds. per acre.

N as ammonium sulphate P_2O_5 as super; K_2O as Potassium Sulphate.

Treatments per acre.				Experimental plot.	
N	P_2O_5	K_2O		(a) 5 E.S.H.	(b) 4 C.H.
No manure				8.1	6.4
...	120	...	...	10.7	8.1
40	120	...	...	15.6	14.2
...	120	160	...	10.8	8.1
40	120	160	...	16.5	15.4
General mean.				12.33	10.43
Critical difference (5% level)				2.10	1.98

In both cases application of Super-phosphate to berseem significantly increased the yield of maize crop following berseem. Addition of Nitrogen significantly augmented the yield. Potash did not appear to influence the yield of maize succeeding the fertilised berseem crop.

2. Flood water farming experiment

The flood farming experiments in progress at Karnal are identical to those running at the Indian Agricultural Research Institute, New Delhi. During the year extensive rains in September saturated the soil strata to almost equal depths in both cases. Benefit or deleterious effect on crop yield if any was exhibited by keeping the land in wet condition during July and August. The crops under experiment were wheat, barley, gram and *toria*. The out turns of the crops are given below :—

TABLE XI.

Yield in mds. per acre.

Manurial Treatments per acre		soil moisture treatments	Wheat	Crops under experiments.		
			Barley	Gram	Toria.	
No manure.		Flooded	20.98	24.72	8.58	9.31
		Rainfed	16.18	29.35	11.14	9.47
40 lbs. N applied as Ammonium		Flooded	24.63	25.77	7.72	12.03
—Sulphate.		Rainfed	16.02	26.91	9.84	9.59
40 lbs. N + 110 lbs. P_2O_5		Flooded	20.41	25.77	9.07	12.11
applied as ammonium phosphate.		Rainfed	19.43	28.62	10.33	9.92
Mean yield		Flooded	22.01	25.42	8.46	11.15
		Rainfed	17.21	28.29	10.43	9.06

Flooding improved the yield of wheat and *toria* but depressed the out-turn of barley and gram. The effect of manuring was not significantly evident on any of four crops under experiment.

3. Mixed farming experiments.

Three mixed farming holdings have sizes of 8, 25 and 400 acres. The 400 acres holding is mechanically cultivated. The cropping was carried out according to programme. *Khariff* grain crops rather yielded low return. The cash crop of sugarcane came up normally and fetched high price. Profit and loss account of each of these holdings was maintained as usual.

4. Experiments on small cultivator Holdings.

With a view to make an integrated approach to the problem of agricultural industry a set of five 6 acre cultivator's holdings have been started. One of these is a *barani* holding. Improved agronomical practices have been adopted to derive the maximum yield of grain, feed fodder and cash was enough to maintain an average size cultivator's family, together with a pair of bullocks. Farm accounts are being maintained to work out balance sheet at the close of each rotation of crops. This will be reported in due course.

IV.—MISCELLANEOUS

(a) *Machinery and agricultural operations*.—All the tractors except one D4 and one bull dog (light) tractor were lying out of commission for lack of spares. Towards the close of the year, the supply position of spares improved and repair of T.D. 14, W. D. 40 No. 1614 was taken in hand. Thus the basic cultivation operations were performed with very great difficulty. Chopper G.S. refused to yield further service. Marshall Thresher No. 1, was repaired for threshing of Oats crop. One tractor mover worked during the season. Steadily the equipment is being received to facilitate normal running of the farm.

(b) *Irrigation*.—Rotational supply of 7.3 cusecs of water continued to be received during the season. Paddy area was mostly irrigated from the special outlet. The seasonal outlet operated from 15th July to 15th September to supply irrigation for flood water farming experiments. In the closing month of the year, drilling of tube well in Block No. 5 was taken in hand.

(c) *Seed supply*.—About 49 maunds seed of paddy was distributed amongst the cultivators who have migrated from rice-tractors of the West Punjab. There was greater demand for finer rice types. It is proposed to multiply them more extensively. Wheat seed could not be despatched owing to restrictions on booking. About 350 maunds wheat seed of N.P. 165, N.P. 4 and N.P. 125 has been reserved for Delhi Province Development scheme. Another 100 maunds wheat seed of C.518 will be supplied to Department of Agriculture, East Punjab for multiplication as nucleus stock on their own farm.

(d) *Hay and silage*.—Approximately 800 maunds of berseem hay in swath was prepared for supply to dairy milch stock to meet fodder scarcity demands. A total of Jowar silage was supplied to live stock.

(e) *Usar (Alkali) control*.—Paddy-berseem rotation fertilized with phosphate (to legume) is proving a good methods of "Usar" reclamation.

Cattle Breeding and Management

I. *General*.—The two-fold object of maintaining Tharparkar herd at Karnal is firstly, to investigate the potentiality of Tharparkar cows for milk yield while retaining their fine quality of draught animals and secondly, to experiment on a large scale on the practice of mixed farming. Subsidiary to these two objectives, experiments on premilking of pregnant cows, three weeks in advances of cowing, on early maturity of cows and bulls, on reducing the long dry period in dry stock, on rearing of calves, management of breeding stock and statistical examination of dairy and breeding data.

II. *Strength of the herd*.—The herd strength at the close of the year was 391 which consisted of 74 cows were in milk, 46 dry cows, 105 young male stock, 85 young female stock, 14 bulls and 67 young calves. This represents an increase of 95.5 per cent. on normal strength and 12.7 per cent. increase over last year's strength at the close of the year.

III. *Milk yield*.—Of the 80 cows completing their lactations, 26 were heifers. The performance of the herd is classified as under :—

Milk yield group lbs.	No. of cows.	Per cent of Total	No. of heifers.	Percent. of Total
Below 2000	3	3.7	1	3.8
2001 to 3000	4	5.0	1	3.8
3001 to 4000	8	10.0	3	11.5
4001 to 5000	9	11.2	4	15.4
5001 to 6000	17	21.2	8	30.8
6001 to 7000	22	27.6	7	27.0
7001 to 8000	10	12.6	2	7.7
8001 to 9000	6	7.5	...	...
9001 to 10000	1	1.2	...	...

Of all the cows 70 per cent. yielded above 500 lbs. per lactation—similarly 65 per cent. of the heifers did over 5000 lbs. within 10 months period. Cow Hasrami yielded over 9000 lbs. in her 4th lactation. The milking average for the whole herd was 20.0 lbs. per cow per day. The milking average was depressed during the period September to December owing to non-availability of oil cake and common salt. Four times milking of cows was continued. About 2/3 of the cows were maintained in milk.

IV. *Premilking of cows*.—Premilking of cows before they calve resulted in their flushing within 2 to 3 weeks as compared to the normal of 7-8 weeks after calving of cows. The flush was thus maintained for a longer period than usual. A fewer animals developed mastitis.

V. *Breeding*.—Fourteen bulls were under test. Except two rest 12 come from the 'Kurwell' and 'Kurnol' lines. Progeny tests revealed bull Tikka to possess high prepo-

tency for milk. He is from 'Kurnol' line. Two of his daughters have yielded over 10,000 lbs. of milk. Bull 'Faizal' was found to have poor prepotency for milk yield. Bull Bulwant from 'Kurwell' line appears to be imparting high yielding characters to its daughters. Bull Gama, being very old, is being retired from services.

VI. *Feeding and growth of animals.*—(a) *Adult stock.*—Concentrate ration largely comprised a ration of cereals, principally oats and wheat screenings. Gram was in short supply. Bran was conspicuously absent from the ration. Oil cakes and salt were unobtainable from September to December. All this happened owing to dislocation of normal transport in the East Punjab. Normal supply of feeds except Bran was arranged from December. Bran began to be supplied from May, 1948. This affected both the Milk yield and growth of animals. The milking average was depressed during the period September to December. The real improvement began from May onwards.

Bulk of fodder supply consisted of *jowar* from July to December as green and silage. It was supplemented by cowpeas. Berseem began to be supplied from November and this continued upto end of May. About 500 mds. of berseem hay was supplied to milch animals.

Heifers on the average gained weight of 12.2 lbs. per year. Most of the adult cows remained in condition inspite of the strain of fourtimes milking. On the average the daily rate of growth of the young stock was 0.4 lbs. The bulls maintained their normal health.

(b) *Calf rearing.*—The improved system of calf handling continued to be employed for rearing calves. They were fed with 'churn' flour to make up mineral deficiency. The rate of growth of calves upto 3, 6, 9 and 12 months ages were 0.8, 0.7, 0.7 and 0.85 lbs. per day which was quite satisfactory.

VII. *Breeding stock sales.*—Eleven bulls were supplied to the livestock Expert, Bihar for distribution as stud bulls there. Ten cows were disposed off as surplus to the stock for grading up the herd. There appears to be good demand for Tharparkar bulls as it has found that this breed has dual qualities of draught and milk production.

IV.—STATISTICAL SECTION

As in previous years, the section of statistics attended to a large volume of work in designing of field experiments and analysis of the results. Besides teaching of post-graduate students and advisory work, the section attended to the following investigations of the various Divisions.

1. *Review of the Results of the New Manurial experiments at Pusa.*

The results of these experiments, the details of which were given in the past reports of the Botanical Sub-Station at Pusa are reviewed for the period 1932 up-to-date. The experiments were started with a view to obtain statistically significant results from the manuring programme followed in the Permanent Manurial and Rotation Experiments at Pusa. The rotation followed in all the plots is four year, eight-course rotation.

- (i) Maize, oats.
- (ii) Maize, peas.
- (iii) Maize, wheat.
- (iv) Maize, gram.

All the manures excepting F.Y.M. are applied half in *rabi* and half in *Kharif* while F.Y.M. is applied to the main crop. Table I gives the average yields of all the crops from 1932 up-to-date. The analysis of variance has shown that there are significant differences between years and treatments as also their interaction in the case of all the crops.

Maize.—Rape cake at 40 lbs. N per acre has given the best results exceeding the group of manures F.Y.M. at 8,000 lbs., combination of ammonium sulphate and superphosphate, ammonium sulphate, superphosphate and Potassium sulphate significantly. Between F.Y.M., N.P. and N.P.K. there are no significant differences. This group exceeds significantly the treatments ammonium sulphate with or without potassium sulphate. Between these two, there is no significant differences. The treatments without N have not shown any response over the control. The order of response is given below :

						Yield in lbs. per acre	% increase over control.
(1)	Rape cake	...	...	...	...	547	164
(2)	(i) F.Y.M. at 8000 lbs.	...	...	...	...	401	94
	(ii) Ammonium sulphate and superphosphate	...	...	...	...	403	94
	(iii) Ammonium sulphate, superphosphate and potassium sulphate.	...	...	...	...	395	91
(3)	(i) Ammonium sulphate	...	...	...	...	340	64
	(ii) Ammonium sulphate and potassium sulphate	...	...	...	...	336	62
(4)	(i) Superphosphate	...	...	...	...	260	...
	(ii) Potassium sulphate	...	...	...	...	231	...
	(iii) Super+Potassium sulphate	...	...	...	...	204	...
	(iv) No manure	...	...	...	...	207	...

Oats.—The highest yield was obtained by the combination of N, P. and K. Between this, F.Y.M. at 8,000 lbs. per acre, NP and Rape cake, the differences are not significant. The treatments receiving N, ammonium sulphate, and ammonium sulphate and potassium sulphate are just showing response at the 5% level. The treatments P, K, PK without N have shown no response. The order is given below :

						Yield in lbs per acre.	% increase over control
NPK	...	...	...	...	...	813	107
F.Y.M. 8000 lbs.	...	...	...	...	...	799	103
NP	...	...	...	...	...	758	93
Rape Cake	...	...	...	...	...	692	76
NK	...	...	...	...	...	537	37
N	...	...	...	...	...	502	28
P	...	...	...	...	...	487	...
K	...	...	...	...	...	456	...
PK	...	...	...	...	...	392	...
O	...	...	...	...	...	393	...

Peas.—With peas, F.Y.M. has given the best results. This just approaches significant difference at 5% level from the Group of those inorganics receiving superphosphate, and rape cake at 40 lbs. N per acre. In this Group receiving P and rape cake,

the differences are not significant. Those not receiving superphosphate, *viz.*, N. K. NK do not show any response over the control. The order of response is given below :

						Yield in lbs. per acre	% increase over control
(1)	F.Y.M.	...	...	...	...	474	121
(2)	(i) NP	...	...	...	...	390	82
	(ii) P	...	...	...	...	383	79
	(iii) PK	...	...	...	...	367	71
	(iv) NPK	...	...	...	...	363	70
	(v) Rape cake	...	...	...	...	375	75
(3)	(i) N	...	...	...	...	203	
	(ii) K	...	...	...	...	246	...
	(iii) NK	...	...	...	...	203	
	(iv) No manure	...	...	...	...	214	

Wheat.—F.Y.M. has given the best results though it is not significantly different from Rape cake and NPK and NP. F.Y.M., NPK and NP are significantly better than those inorganic manures not receiving P., *viz.*, N.K. and N. There are no significant differences between N.K., N. and rape cake and this Group is significantly better than the inorganic manures P, K. and P.K. and control. The former P, K. and P.K. have not shown any response. The order of response is given below :

						Yield in lbs. per acre	% Response over control.
	F.Y.M.	...	...	...	...	496	83
	NPK	...	...	...	...	466	72
	NP	...	...	...	...	463	71
	Rape Cake	...	...	...	...	414	53
(2)	NK	...	...	...	...	385	42
	N	...	...	...	...	371	37
(3)	K.	...	...	...	...	278	...
	P	...	...	...	...	291	...
	KP	...	...	...	...	246	...
	Control	...	...	...	...	271	...

Grams.—In this crop, the best results are given by F.Y.M. though it does not differ significantly from rape cake, and inorganic manures containing superphosphate with or without N. or K. The differences between any two treatments in this Group are not significant. This Group is significantly better than the Group not receiving superphosphate, *viz.*, N. K. NK and control. The order of response is as follows :—

						lbs. per acre	% increase over control.
I	F.Y.M.	...	...	...	...	586	81
	P	...	...	...	...	566	75
	NP	...	...	...	...	541	67
	PK	...	...	...	...	527	63
	NPK	...	...	...	...	497	54
	Rape Cake	...	...	...	...	496	
II	No manure	...	...	...	...	386	
	N	...	...	...	...	328	...
	K	...	...	...	...	328	
	NK	...	...	...	...	323	

2. Review of Permanent Manurial and Rotation Experiments at Pusa (1930).

These experiments were started in 1908 with a view to study the conditions which determine soil fertility in a sub-tropical climate, especially the effect due to the application of the important organic and inorganic manures and the inclusion of rotations with legumes and green manures. The results of the experiments with the original two-year four course rotation were reviewed by the Board of Agriculture in 1929. The rotation was changed to four-year, eight course rotation. The details of the experiments will be found in the Reports of the Division of Botany.

Results for maize.—Table II gives the average yields of maize in lbs. per acre from 1930-47. The yields varied from 277 to 1,298 in A series and 233 to 1,237 in B series.

At the two blocks differ in fertility, the results are separately given for each Block. The no manure plots show large variation especially plots I and 18 are superior to 13 in the middle, and the average is taken in comparisons.

Effect of organic manures.

			A Block		B Block	
			Yield in	% increase	Yield in	% increase
			lbs. p/a		lbs. p/a	
(1)	Control	...	370	...	314	...
	F.Y.M. 4000 lbs.	...	928	151	880	180
	F.Y.M. 8000 lbs.	...	1223	231	1102	248
F.Y.M. & Rape 4000 lbs. cake						
	20 lbs. N	...	1298	251	1237	294
	Rape cake alone 40 lbs. N	...	1007	172	888	183

The results show that F.Y.M. at 4,000 lbs. and rape cake 20 lbs. N has given the best response in both the Blocks, exceeding F.Y.M. at 3,000 lbs. alone slightly. There is a suggestion that a mixture of F.Y.M. and Rape cake is likely to give better result than F.Y.M. alone or equivalent N in Rape cake.

Effect of inorganic Manures.

			A Block		B Block	
			Av. Yield	% increase or	Av. Yield	% increase
			in lb/acre	decrease	in lbs/acre	or decrease
(1)	Control	...	370	—	314	—
(2)	Amm. Sulphate (N)	...	361	— 2	286	— 9
(3)	Pot. Sulphate (K)	...	343	— 7	280	— 11
(4)	Superphosphate (P)	...	612	+ 65	490	+ 56
(5)	NK	...	316	— 15	294	— 6
(6)	KP	...	543	+ 47	524	+ 67
(7)	NP	...	436	+ 18	505	+ 61
(8)	NPK	...	770	+ 108	689	+ 119

The results clearly show that nitrogen and potash applied alone or N+K have not given any response. On the other hand superphosphate has given decided increases over the control either alone or in combination with N. and K. or both. The complete mineral has given decided increases over P. alone and other combinations of N. P. and K. Comparing the performance of organic manures with inorganics, the results show

that the responses given by organic manures are far higher than even the complete mineral.

Effect of Rotations.

Block A				Block B			
		Av. Yield in lbs/acre.	% increase			Av. Yield in lbs. acre.	% increase
Control	...	370	...			314	...
No legume or G.M. purely cereal rotation	...	441	+ 19			343	+ 9
G. M. in cereal	...	...	...			...	...
Legume and G. M.	...	596	+ 61			531	+ 69
Legume & G. M. with super	...	797	+115			795	+153

The results show that the purely cereal rotation has not shown any difference from the control and is very unsatisfactory. Inclusion of a legume and green manure in the rotation has shown response which is further increased by the addition of superphosphate to Green Manure.

Effect on Barley and Wheat.

Table 3 gives the yields of the two cereal crops Barley and wheat. For barley and wheat the best results are given by F.Y.M. at 8,000 lbs. and F.Y.M. at 4,000 lbs. and Rape Cake 20 lbs. N. All the organic manures have shown considerable response in the case of both the crops. Among the inorganic manures, in both the cereal crops, the treatments N, K. and N.K. without phosphorous have not shown any response. The best results are obtained by the complete mineral, NP. K. NP. and P. in order. Potassium has a depressing effect along with P without N, showing that nitrogen is the secondary limiting factor.

The effect of rotations.

The results show that purely cereal rotation has given very low yields—inclusion of green manure has increased the yields slightly. The inclusion of both legume and green manure has given responses of the order of 182% in the case of Barley in A, 161% in B and of 88% in the case of wheat in A and of 130% in B. Spectacularly high responses are obtained by applying superphosphate to the Green Manure Crop. The yields obtained are nearly twice the yields obtained with the best manurial treatment. The following summarises the results and order of response.

Barley						Wheat			
A		B		A		B			
Yield in lb. per acre	% in- crease over control	Yield in lb. per acre	% in- crease over control	Yield in lb. per acre	% in- crease over control	Yield in lb. per acre	% in- crease over control		
Control	...	305	...	319	...	241	...		
F.Y.M. 8000 lbs.	936	857	181	892	180	920	282		
N. P. K.	1069	1160	280	752	136	687	185		
Legume+G.M.	745	795	161	599	88	554	130		
Legume G.M. with Super	2063	1707	460	1504	371	1544	541		

Effect on Arhar and Peas.

Table 4 shows the results of the experiments for the two crops arhar and peas. All the organic manures have shown good response, the best results being obtained by F.Y.M. at 8,000 lbs. per acre in the case of both the crops. As in other crops, there are no responses to the application of inorganic manures to supply N, K or NK alone. The treatments with phosphorous have given definite responses, the highest yields being obtained with N.P. Addition of K has slightly depressed the yield. For studying the effect of rotations only three comparisons are possible, legume, G.M. rotation with or without superphosphate and control. The legume, G.M. rotation without super has not shown any appreciable response to these two crops but addition of superphosphate has given decided increases. The following brings a comparison of the responses obtained by F.Y.M., NP and Legume, G.M. Rotation with or without super.

Arhar						Peas			
A		B		A		B			
Yield	% in-crease	Yield	% in-crease	Yield	% in-crease	Yield	% in-crease	Yield	% in-crease
Control	458	...	498	...	193	...	129	...	...
F.Y.M. 800 lbs.	954	108	1108	123	682	253	488	278	...
NP	1032	125	1323	166	533	176	422	227	...
Legume & G. M. Rotation	482	5	500	...	247	28	197	53	...
Legume & G.M. with super	878	92	1057	112	590	206	705	447	...

III. *Mineral Balance Experiments with Dairy Cows.*—The data of the Mineral Balance experiments with 4 lactating cows fed on (a) Unmanured Berseem (b) Manured Berseem (c) Green Lucerne (d) Jowar Silage was analysed.

The experiment was designed to study the effect of these feeds on the mineral Balance of dairy cows of the Sahiwal herd. The following are the details of the experimental animals and Rations :—

				Treatments			
				(6 days expt. and 6 days rest)			
				A	B	C	D
Lenjurki (3rd Calver)	...	...	21-3-46	B	C	D	A
Laraj Beni (2nd ")	...	...	25-3-46	C	D	A	B
Haskila " "	...	...	8-3-46	D	A	B	C
Yulamati " "	...	...	8-3-46				

Calcium.—The analysis of variance showed that there are significant differences between the cows in their Mineral Balances as also between the treatments and the four experimental periods. The mineral Balances for calcium under the four fodders with a supplement of chalk are given below :—

							Average Balance
Unmanured Berseem	...	...	...	...	...	...	+ 9.18
Manured Berseem (Manured with Amm. phosphate)	...	...	...	...	...	...	+ 14.32
Green Lucerne + Lucerne Hay	...	...	...	...	...	...	+ 9.86
Jowar Silage	...	...	...	...	...	...	+ 5.45
C. D. at (5%)	...	...	...	...	...	...	2.00

The manured berseem is significantly different from the rest in creating positive balances. Between unmanured berseem and green lucerne, lucerne hay the differences are not significant Jowar silage is significantly inferior to other fodders in creating positive calcium balances.

Phosphorous.—For phosphorous balances, the treatments are not significant.

							Average Balance
Unmanured Berseem	...	...	...	...	...	...	- 12.01
Manured Berseem	...	...	...	...	...	...	- 1.87
Green Lucerne + Lucerne Hay	...	...	...	...	...	...	- 8.57
Jowar Silage	...	...	...	...	...	...	- 4.78
C. D. at (5%)	..	...	...	...	...	...	14.51

Unmanured berseem has created significant negative Balance. The other Balances are not significantly different from zero.

Sodium.—Here also the treatments are not significant. The following are the mineral balances under the various fodders supplemented by salt :

							Average Balance
Unmanured Berseem	...	...	...	...	...	...	+ 6.74
Manured Berseem	...	...	...	...	...	...	+ 10.68
Green Lucerne and Lucerne Hay	...	...	...	...	...	...	- 12.55
Jowar Silage	...	...	...	...	...	...	- 6.63
C. D. at (5%)	...	...	...	...	...	...	11.23

Manured berseem has created significant positive balance while green lucerne and lucerne hay created significant negative balance. The balances with other minerals are either maintained or positive.

The other investigations included the analysis of the pot-culture experiments of the Division of Chemistry, the data on the effect of different nutrients on the longevity and fecundity of the parasites *Trichogramma Evanescens minutum* and preliminary work for the analysis of the Dairy records of the Tharparkar herd at Karnal.

TABLE 1.

New Manurial Experiment at Pusa 1932.

	Yield in lbs. per acre.	Yield in lbs. per acre.	Yield in lbs. per acre.	Yield in lbs. per acre.	Yield in lbs. per acre.
	MAIZE	OATS	PEAS	WHEAT	GRAM
A. No manure	207.27	393.04	213.71	271.05	385.60
B. F. Y. M. at 8000 lbs.	421.03	798.90	473.95	495.64	586.00
C. Rape cake at 40 lbs. N	547.12	692.47	375.40	413.77	496.00
D. Sulphate of ammonia 40 lbs. N.	339.64	502.42	203.26	370.61	328.08
E. Sulphate of Potash 50 lbs. K ₂ O (K)	231.33	455.82	245.81	278.22	327.60
F. Superphosphate 80 lbs. P ₂ O ₅ (P)	259.88	486.86	382.53	291.82	566.00
G. K + P	203.59	391.97	367.12	246.10	527.60
H. N + P + K	395.46	812.78	363.27	466.39	496.80
I. N + P	403.36	758.16	390.07	463.33	541.20
J. N + K	336.27	536.59	203.36	384.89	323.20
C. D. at 1%	89.85	166.40	114.80	76.40	112.80
C. D. at 5%	67.70	125.20	86.40	57.60	84.80

TABLE 2.
Permanent Manurial and Rotation Experiments Pusa 1930-47.
Maize yields in lbs. per acre.

	A series				B series
1. Control	...	...	410	395	
	...	...	421	313	
	...	...	277	233	
	370				314
2. Organic Manure					
(i) F. Y. M. 4000 lbs.	...	...	928	880	
(ii) F. Y. M. 8000 lbs.	...	...	1223	1102	
(iii) F. Y. M. + Rape cake	...	...	1298	1237	
(iv) Rape cake alone	...	...	1007	888	
3. Inorganic Manures.					
N	...	...	361	286	
K	...	...	343	280	
P	...	...	612	490	
NK	...	...	316	294	
KP	...	...	543	524	
NP	...	...	436	505	
NPK	...	...	770	689	
4. Rotations:—					
(i) G. M. in cereal	...	...	...	...	
(ii) Legume & G. M.	...	...	596	531	
(iii) (ii) + Super	...	...	797	795	
(iv) No legume or G. M.	...	...	441	343	

TABLE 3.
Effect on Barley and Wheat.

Barley					Wheat				
		A	B		A	B			
6	Yield	% increase	Yield	% increase	Yield	% increase	Yield	% increase	
Control	264	...	305	...	319	...	241	...	
F. Y. M. 4000 lbs.	535	103	491	61	683	114	576	139	
8000 lbs.	936	255	857	181	892	180	920	282	
F. Y. M. & Rape cake	884	235	894	193	810	154	687	185	
Rape cake	728	176	596	95	568	78	441	83	
Inorganic Manures:—									
Control	264	...	305	...	319	...	241	...	
N	363	38	343	12	318	-0.3	245	2	
K	353	34	298	-2	315	-1	224	-7	
P	891	238	683	124	620	94	513	13	
KP	565	114	592	94	538	69	579	140	
NPK	1069	305	1160	280	752	136	687	185	
NP	1005	281	970	218	705	121	631	162	
NK	427	62	416	36	394	24	313	30	
Rotations:—									
Control	264	...	305	...	319	...	241	...	
G. M. in cereal	443	68	410	34	394	24	313	30	
Cereal w/o G. M.									
or Legume	195	-26	199	-35	195	-39	166	-31	
Legume & G. M.	745	182	795	161	599	88	554	130	
Super	2063	681	1707	460	1504	371	1544	541	

TABLE 4.

*Effect on Arhar and Peas.**Permanent Manurial Experiments at Pusa 1930.**Yields of Arhar and Peas in lbs. per acre.*

		Arhar				Peas			
		Block A		Block B		Block A		Block B	
		Yield	% increase over control.	Yield	% increase over control.	Yield	% increase over control.	Yield	% increase over control.
Control									
Plot 1	...	659	...	564	...	234	...	161	...
„ 13	...	375	- 43	439	- 22	174	- 26	116	- 28
„ 18	...	340	- 48	492	- 13	172	- 27	109	- 32
Average	...	458	- 31	498	- 12	193	- 18	129	- 20
Organic Manures:									
F. Y. M. 4000 lbs.	...	900	37	914	62	361	54	296	84
8000 lbs.	...	954	45	1108	96	682	191	488	203
F. Y. M. 4000 lbs. + Rape cake 20 lbs. N	...	809	22	960	70	616	163	414	157
Rape Cake 40 lbs. N	...	769	17	706	25	307	31	274	70
Inorganic Manures:									
N	...	718	9	657	16	151	- 35	136	- 15
K	...	527	- 20	448	- 21	183	- 22	139	- 14
P	...	990	50	1066	89	516	21	375	133
KP	...	723	10	1034	83	484	106	443	175
NPK	...	858	30	1049	86	493	111	422	162
NP	...	1032	57	1323	135	533	128	422	162
NK	...	316	- 52	495	- 12	104	- 56	102	- 37
Rotations:									
Cereal Rotation (without G. M. or legume)									
G. M. in cereal	...	...	...	...	...	...	...	...	...
Legume & G. M.									
Rotation	...	482	- 27	500	- 11	247	6	197	22
Legume & G. M. with super									
with super	...	878	33	1057	87	590	152	705	338

V.—PROGRAMME OF WORK (1948-49)

AGRONOMY

1. *Soil fertility problems.*—(a) *Manurial experiments* :—

(i) *Nitrogenous manures and fertilizers.*—Experiments to test the relative values of nitrogen in organic and inorganic manures and also responses of their combinations on wheat maize and paddy.

(ii) *Phosphatic fertilizers.*—Experiments with the different forms of phosphatic fertilizers to study their responses on *Kharif* and *rabi* legumes and after-effects on cereals following the legumes.

(iii) *Nitrogenous and phosphatic fertilizers.*—To study the relative merits of different types of nitrogenous and phosphatic fertilizers at ten Experimental Stations all over India.

(iv) *Nitrogenous, phosphatic, potassic and calcium fertilizers.*—Experiment to study the effect of these each at three levels and in all possible combinations on the yield of wheat.

(v) *Green manures.*—Experiments with different legumes as green manures with and without fertilizers on wheat. Experiments to study the effect of green manuring when the crop is grown *in situ* and brought from outside.

(vi) *Permanent Manurial and New Manurial experiments of Pusa.*—The experiments will be conducted under the supervision of this Division.

(b) *Placement of fertilizers.*—To effect economy in the quantity of fertilizer used and their better utilisation by field crops.

(c) *Mixed Cropping.*—To study the possibility of maintaining soil fertility by growing a mixture of cereals and legumes under different fertilizer treatments.

(d) *Mixed farming.*—To obtain maximum overall yields which a cultivator is likely to get from holdings of 6 acres under irrigated and unirrigated conditions designed to meet the requirements of his family members and cattle.

2. *Irrigation experiments.*—To find the water requirements of sugarcane.

3. *Cultural experiments.*—On sugarcane, gram and potato.

4. *Varietal yield trials.*—Experiments will be conducted with improved varieties of different crops.

5. *Agrostology.*—To produce high yielding and palatable fodder grasses and legumes for cattle. To increase the productivity of natural grasslands. To work out suitable seed mixtures of grasses and legumes for pasture. To work out a suitable system of lev farming.

Cattle breeding and management.

1. Line breeding and selection for improvement of milk yield.

2. Handling of the stock for the development of milk temperament.

3. Feeding of stock on balanced rations for growth, early maturity and high milk production.

4. Four times milking as a means of stimulation for the production of high yield.

5. Pre-milking as a means of stimulation for milk production, to train heifers to milk before calving and to prevent under trouble.

6. Calf rearing on standardised milk ration containing 3.5 per cent. butter fat.

7. Early maturity treatments to test bulls for their transmitting capacity of high milk yield quality at an early age.

Report of the Head of the Division of Botany

I.—INTRODUCTORY

Progress in respect of the programme for research and post-graduate training was maintained during the year under review though shortage of staff was a handicap. The posts of Cytogeneticist, Systematic Botanist, Assistant Cytogeneticist and Assistant Geneticist remained vacant. Owing to the resignation of Dr. J. J. Chinoy, the post of Assistant Plant Physiologist also remained vacant for a major part of the year; it has, however, been filled up recently by the appointment of Mr. T. J. Malkani. Mr. A. B. Joshi, Assistant Cytogeneticist, left in August 1947 for higher studies at Cambridge. Certain members of the staff left for Pakistan and some posts of Senior and Junior Scientific Assistants could be filled only recently. Dr. N. Parthasarathy joined the Division as Geneticist on 1st November 1947.

In addition to the permanent Substation at Pusa the following schemes financed by the Indian Council of Agricultural Research continued to function under the Division :

Potato Breeding Scheme (located at Simla and Bhowali).

Wheat Breeding Scheme for the Hills (located at Simla).

Scheme for the Introduction of Economic Plants.

Scheme for the Improvement of the Maize Crop in India.

The work of the Substation at Pusa was carried on under difficulties as the Superintendent of the Substation left in August 1947 for Pakistan.

Also many of the posts in the Schemes remained vacant.

The scheme for testing the germination and quality of vegetable seeds came to a close on 22nd October 1947.

The results obtained at the Substation at Pusa and the schemes mentioned above are briefly referred to in this report.

Considerable attention was paid to the training of post-graduate students. Research Fellows and Honorary Researchers were guided in their research.

II.—RESEARCH

APPLIED GENETICS

1. Study and improvement of Indian Wheat (*Triticum* spp.)

The all-India collection of wheats was grown and observations on a few important characters were recorded. The detailed studies of the collection could not, however, be continued for want of staff. Some of the cultures were very badly attacked by yellow rust so that only a few shrivelled grains were obtained.

The different varieties of wheat under study for registration were grown for maintenance and observations on a few characters were recorded.

The collection of the wild and cultivated species of *Triticum* and allied genera was under study as in the previous years and further observations were recorded in the progenies of the interspecific and intergeneric crosses and suitable selections made for further study. Thirteen wheat $\times$ *Agropyron* hybrids received from Dr. Hudson of Cambridge, were studied with regard to fertility, grain development and maturity. Under the normal day-length all the hybrids matured late.

Breeding for rust resistance was continued. Thirty-five selections from crosses made originally at Simla and subjected to artificial tests for adult resistance in the previous years were laid down in a preliminary yield trial. Most of them maintained a high degree of rust resistance. The early and medium selections yielded comparatively better than the controls N.P. 4 and N.P. 114; the late-maturing selections, on the other hand, formed good grains, although their yield was slightly lower. These late selections might be useful in regions of longer growing periods. A portion of the progeny of the synthetic cross W375, made with a view to combining resistance to all the 3 rusts, was tested for adult resistance and suitable selections made for further study. The wheat cultures sent by Prof. McFadden from the United States of America and kindly made available to us by the Director of Agriculture, Jaipur, were studied with regard to rust resistance and other important characters. Some of them appeared promising as breeding material.

Progress was made in testing of varieties, including new strains of hybrid origin for resistance to loose smut in co-operation with the Division of Mycology. Forty strains of hybrids evolved at Simla out of the sixty-six tested showed complete resistance, while only a low degree of susceptibility (1 to 15 per cent infection) was observed in many others. A detailed reference is made in the report of the Division of Mycology.

The "N.P." wheats of hybrid origin which have been recently evolved in this Division were again put under yield tests as in the previous year in order to have an idea as to their suitability for different tracts. The tests were conducted at seventeen different places (1 in Orissa, 4 in Bihar, 3 in U.P., 1 in Delhi, 1 in East Punjab, 2 in C.P., 2 in Jaipur, 1 each in Ajmer, Alwar and Bombay) in India. Due to transport difficulties seeds for the trials which were supplied from the Indian Agricultural Research Institute, New Delhi and the Botanical Substation, Pusa, did not reach certain experimental stations in time and the sowing was consequently much delayed there. The results which were at hand at the time of writing indicated that as compared with the local wheats the new strains did very well at each station. Some of them showed a considerable degree of rust-resistance also. A consolidated statement of the summaries of results with regard to grain yields is given below :

WHEAT YIELD TRIALS, 1947-48

	I. A. R. I. (New Delhi)			GORAKHPUR (U.P.)			B.S.S., PUSA* (Bihar)			SEPAYA (Bihar)			PATNA (Bihar)			SABOUR (Bihar)			KUJANG (Orissa)			BASI (Jaipur State)			DURGAPURA (Jaipur State)			ALWAR† (Alwar State)			JUBBULPORE (C.P.)			POWARKHERA (C.P.)			PADEGAON (Bombay)		
Order of merit	Variety	Yield in lbs per acre	Percentage increase over control.	Variety	Yield in lbs per acre	Percentage increase over control.	Variety	Yield in lbs. —per acre	Percentage increase over control.	Variety	Yield in lbs. —per acre	Percentage increase over control.	Variety	Yield in lbs. —per acre	Percentage increase over control.	Variety	Yield in lbs. —per acre	Percentage increase over control.	Variety	Yield in lbs. —per acre	Percentage increase over control.	Variety	Yield in lbs. —per acre	Percentage increase over control.	Variety	Yield in lbs. —per acre	Percentage increase over control.	Variety	Yield in lbs. —per acre	Percentage increase over control.	Variety	Yield in lbs. —per acre	Percentage increase over control.	Variety	Yield in lbs. —per acre	Percentage increase over control.			
1	Ph. C. 518	1,681	...	755	931	+ 1.8	745	13.16	+28.4	710	88	+144.4	762	431	+27.5	710	865	+ 5.4	761	413	+20.4	718	1642	+104.9	758	2227	+45.9	771	46.0	...	775	605	+31.5	775	275	+27.3	710	501	+17.3
2	758	1,621	3.6	761	926	+ 3.9	710	12.83	+25.2	762	88	+144.4	758	380	+12.4	52	821	...	737	413	+20.4	710	1564	+ 95.2	715	2173	+42.4	704	42.5	...	762	583	+26.8	715	268	+21.0	715	482	+12.9
3	761	1,590	5.4	760	922	+ 3.4	760	12.58	+22.7	761	83	+130.6	710	368	+ 8.9	760	735	-10.5	52	343	...	758	1467	+ 83.5	720	2081	+36.4	710	41.3	...	715	582	+26.4	745	262	+21.3	758	475	+11.1
4	718	1,561	7.0	758	916	+ 2.7	720	12.46	+21.6	715	78	+116.7	764	364	+ 7.7	764	726	-11.5	760	333	- 2.9	715	1463	+ 82.6	(Pb. C. 591)	2004	+31.3	758	36.3	...	758	542	+17.9	710	256	+18.5	760	448	+ 4.9
5	762	1,561	- 7.0	741	913	+ 2.3	761	11.00	+ 7.3	760	73	+102.8	779	363	+ 7.4	745	678	-17.4	771	272	-20.7	721	1344	+ 67.8	721	1992	+30.5	720	36.0	...	745	518	+12.5	762	248	+14.9	Local	427	...
6	775	1,547	- 8.0	52	892	...	764	10.79	+ 5.3	764	71	+ 97.5	745	360	+ 6.5	737	665	-19.1	710	161	-53.1	775	1318	+ 64.6	718	1992	+30.5	715	35.8	...	718	514	+11.7	761	232	+ 7.4	761	397	- 7.0
7	710	1,526	9.2	745	828	- 7.2	762	10.43	+ 1.8	758	69	+ 91.7	760	360	+ 6.5	761	652	-20.6	761	1278	+ 59.5	775	1904	+24.8	761	1278	+ 59.5	761	33.0	...	761	493	+ 7.1	A.155	216	...	775	396	- 7.2
8	715	1,474	-12.3	760	801	-10.2	747	10.25	...	737	57	+ 58.3	737	360	+ 6.5	762	645	-21.4	720	1185	+ 47.9	762	979	+ 22.2	737	1775	+16.3	762	27.5	...	771	484	+ 5.2	771	122	-43.5	771	208	-51.3
9	720	1,460	-13.1	764	779	-12.7	715	10.17	- 0.8	720	52	+ 44.4	52	338	...	722	599	-27.1	758	595	-27.5	Local	801	...	722	1723	+12.9	722	26.8	...	A.O.90	460	...	720	434	- 5.6	...	...	...
10	Ph. C. 36	1,314	-20.0	762	779	-12.7	737	10.14	- 1.1	720	36	...	722	312	- 7.7	779	465	-43.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11	760	1,310	-20.3	737	729	-18.3	758	9.58	- 6.5	720	34	- 5.6	720	312	- 7.7	779	465	-43.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12	761	1,292	-23.1	779	327	-10.2	779	7.08	-30.9	779	34	- 5.6	720	312	- 7.7	779	465	-43.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
13	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
14	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
G. M.	1,500	...	...	829	...	...	10.87	...	...	65	...	...	359	...	...	673	...	...	323	...	...	12.65	...	...	18.59	...	...	36.1	...	...	515	...	...	224	...	...	411	...	
S. Em.	± 107	...	...	44	...	...	1.01	...	...	...	...	...	...	...	...	± 45	...	...	± 24	...	...	± 60	...	...	± 78	...	...	...	...	...	...	± 36	...	...	± 24	...	...		
C. D. @ 5%	215	...	...	123	...	...	2.25	...	...	...	...	...	...	...	...	127	...	...	71	...	...	170	...	...	220	...	...	...	...	...	...	103	...	...	67	...	...	...	
No. of Replis cations	6	...	...	6	...	...	3	...	...	6	...	...	6	...	...	6	...	...	6	...	...	6	...	...	6	...	...	...	...	2	...	...	6	...	...	6	...	...	

NOTE

- (1) All are N.P. varieties unless otherwise stated.
 - (2) Varieties underlined are controls.
 - (3) S. Em. and C.D. are not stated wherever the variance due to varieties is not significantly different from that due to error.
- * For B.S.S. Pusa yields per plot are given.
† Full data from Alwar are not available.

In almost all the places the highest yield was obtained from the new strains and in many cases the first few positions in order of merit were occupied by them. In one trial (at the Indian Agricultural Research Institute), however, the maximum yield was obtained from Pb. C.518 which was the control; but here also some of the new strains followed it closely, so much so that there was no significant difference between Pb. C.518 and the N.P. wheats in question. In the varietal-cum-manurial experiments referred to later, N.P. 761 was superior to Pb. C.518 at all levels but again the difference was not statistically significant. Some of the new strains are thus quite promising, particularly N.P. 710 which has done very well both last year and this.

The experiment which was conducted last year to study the effect of environmental factors of the previous season on the performance of the crop during the succeeding season was repeated at three places, Delhi, Pusa and Coimbatore. The experiment was laid out in randomised blocks which were divided into as many main plots as there were varieties and the latter were randomised in them. Each main plot was in its turn divided into four sub-plots which were allotted to seeds obtained last year from different places (Delhi, Pusa, Coimbatore and Simla). Observations were recorded on a number of characters including height of plant, tiller number, ear-length, grain yield etc. The results so far available indicated that at Delhi there were appreciable differences between the cultures from seeds of different places with regard to some of the above characters.

The experiment which was conducted last year to determine the response of different varieties of wheat to the different levels of manuring was repeated during the year under report with some changes in the varietal treatments only. The six varietal treatments (five varieties Pb. C.518, N.P. 165, N.P. 125, N.P. 710, N.P. 761 and the sixth treatment being the mixture of the five varieties) were tested against three levels of fertility and the control which did not include any fertilizer. The three levels of fertility were (a) maximum dose—Nitrogen 80 lb. (40 lb. organic and inorganic each), (b) Phosphoric acid 160 lb. and Potash 80 lb., (c) half maximum doses—half the above quantities, and (d) Nitrogen 40 lb. (inorganic) per acre. The experiment was laid out in three randomised blocks, each divided into six main plots allotted to the six varietal treatments. Each main plot in its turn was again divided into four sub-plots which were allotted to the different manurial treatments. Size of a unit plot (gross) was 31' × 16' and that of an ultimate plot 29' × 14'. The fertilizers were applied to the different plots on the day previous to the sowing of seed. Approximately equal number of seeds were sown in different plots to ensure similarity of stand in them. Plants in some of the plots lodged very badly, particularly in two of the blocks.

The observations recorded on vigour, plant height and tiller number showed that in general the higher the level of fertilizer, the greater was the increase in these characters. In many cases however there were no appreciable differences between the manurial treatments T₁, T₂ and T₃, T₄. With regard to yield of grain the effects of manurial

and varietal treatments were significant at 1% and 5% levels of significance respectively. The results are summarised in the following table :—

Average yield in maunds per acre.

Varieties	T ₁ Maximum combination of N. P. K.	T ₂ $\frac{1}{2}$ maximum combination of N. P. K.	T ₃ Only N	T ₄ Control No manure	Mean
V-Pb. C 518 ...	21.51	27.71	19.56	16.85	21.41
V ₁ -N.P. 165 ...	27.28	28.36	21.51	20.76	24.47
V ₂ -N.P. 125 ...	20.86	20.43	15.89	13.36	17.63
V ₃ -N.P. 710 ...	20.97	15.75	19.78	18.58	18.80
V ₄ -N.P. 761 ...	27.06	26.63	25.86	21.08	25.15
V ₅ -Mixture	25.65	19.56	20.54	16.40	20.54
Mean	23.89	23.07	20.52	17.84	21.33

Standard error of the mean for varieties=1.33

" " " " " " manurial treatments = 1.11

C.D. at 5% for varieties = 4.21

C.D. at 5% for manurial treatments = 3.17

Of the four manurial treatments, T₂ gave the best results followed closely by T₁; the next two places were occupied by T₃ and T₄ respectively. There were, however, no significant differences between T₂ and T₁; T₁ and T₃; and T₃ and T₄. With regard to the varieties V₅ gave the maximum yield, followed by V₂, V₁, V₆, V₄ and V₃ in that order. Statistically the results could be expressed as V₅, V₂, V₁, V₆, V₄, V₃.

Suitable crosses have been made and F₁s grown with a view to breeding wheat strains specially suitable for conditions of intensive farming such as are likely to result from the present efforts to improve agriculture in the country.

In connection with the joint study with Mr. Boshi Sen, 50 varieties of wheat from the collection maintained in this Division were vernalised for 68 days at Almora and were sown at Delhi along with untreated seeds for observations. The experiment was laid out in four replications, the varieties being sown in the same order in all the blocks in 3 feet long rows. Two adjacent rows were allotted to each variety, one to treated and the other to untreated seeds. Observations were recorded on individual plants with regard to flowering date, height of plant, number of tillers and yield of grain. The germination of seed in some of the cultures was extremely poor and therefore the averages calculated for them cannot be taken into consideration. The range of earliness (average of four blocks) induced by vernalisation was observed to be 1 to 10 days, although in some of the blocks the earliness was even more in the case of certain varieties. In some varieties, however, no earliness was observed.

Of the 50 varieties, N.P. 735, Jaya, E.S.R., H.S.W., A.T.W., C.S.R. and D.P.H.R. showed marked earliness as compared to the respective controls.

Observations on the extent of natural crossing in three wheat varieties, namely, N.P. 4, 52 and 120, indicated that although seasonal differences contributed to a certain degree towards the extent of natural crossing, varietal differences were more significant. The percentage of natural crossing varied from 0.06 to 0.54 in the 3 varieties.

2. Breeding for Disease Resistance and other Qualities

POTATO (*Solanum tuberosum* L.)

The work on selection of potato hybrids suitable for the plains of India was continued both at Delhi and at the Botanical Substation, Pusa. At Delhi, from amongst the 37 hybrids tried in the previous years, 9 hybrids were selected and put under an yield trial along with the 3 main commercial varieties of the plains, i.e., *Phulwa*, *Darjeeling Red Round* and *Gola*. As a result of observations on growth and vigour, disease incidence, yield, tuber characters and maturity for a number of years, four hybrids out of these, namely, No. 45, 208, 209 and 2236, have been found to be particularly promising. The important characters of these hybrids as well as the local varieties are indicated in the following table :

Hybrid or local variety		Maturity period (days from planting to harvest)	Yield of 100 plants in lb. (Average for 3 years)	Tuber characters
No. 45	...	120	121.9	Large, round tubers of uniform size; medium deep eyes.
No. 208	...	135	101.5	Uniform, medium-sized, round to oval tubers; eyes picked purple-pink, medium-deep.
No. 209	...	127	99.3	Uniform, medium-sized, round to oval tubers; eyes picked purple-pink, medium-deep.
No. 2236	...	113	83.0	Uniform, medium-sized, over tubers; eyes shallow.
Phulwa	...	143	119.5	Small tubers of ununiform size; eyes picked pink, very deep;
Darjeeling Red Round	...	135	100.1	Small to medium-sized red tubers; eyes deep.
Gola	...	113	66.2	Medium-sized tubers with deep eyes.

(The yield of the local varieties refers to the apparently healthy stock).

Taking them as a group, these hybrids are earlier than both *Phulwa* and *Darjeeling Red Round*, the two commercial varieties which together occupy the largest area under potato in the plains of India. In contrast to the commercial varieties, the hybrids possess tubers of large size and good shape. In addition, the hybrids appear to be tolerant, to a certain degree, to the viruses attacking potatoes and are, therefore, less subject to the process of degeneration due to diseases than the commercial varieties of the plains. It is proposed to test these hybrids at a few places in the important potato growing tracts in the plains during the next season.

Another set of 26 hybrids which were found promising in the previous years was put under a preliminary yield trial along with the local varieties mentioned above. Hybrids No. 291, 610, 700, 969, 1217, 1223, 1995 and 2211 gave good performance. All

of them gave higher yields than *Gola* and many of them compared very favourably with *Phulwa* and *Darjeeling Red Round*. Besides, they appeared quite tolerant to the virus diseases.

The performance of hybrids under progeny rows was under test for further selection. Six hundred and thirteen hybrids were grown under observation rows and 360 hybrids were selected for further study.

Preliminary observations on the yielding capacity of plants raised from sprouts showed that the sprouts of the late-maturing variety *Phulwa* did not give as much yield as the whole tubers probably due to unsuitable time of planting of the former. Experiments are in progress to find out the proper time of planting of the sprouts.

At Pusa, selection was made from among nearly 900 hybrids grown under progeny rows. Hybrids No. 59, 557, 567, 1110 and 1134 gave encouraging results. Much of the material stored at this substation was lost due to rotting apparently following carbon bisulphide fumigation against the potato moth.

At Simla a large collection of species, hybrids and commercial varieties recently brought from Cambridge was under study for evaluation from the point of view of its breeding utility or direct introduction. The work on breeding for late blight resistance was continued and strains resistant to late blight and possessing good tubers have been obtained and are awaiting regional trials. The sproutling method was successfully utilized for the multiplication of the important experimental material. The trials with the new hybrids evolved at the station were continued both in the hills and the plains. Hybrids No. 2 and 12 were found to be particularly suitable in the United Provinces while hybrids No. 5 and 9 did well in West Bengal. Both these provincial departments of agriculture sent requests for large quantities of these hybrids for multiplication and distribution in their provinces.

Experiments on the artificial production of chimeras were temporarily discontinued. A comparative study was made of the diploid and the tetraploid *Nicotiana glauca* which was obtained in the previous year as a result of grafting and decapitation. A reference to these observations has been made under the section of Cytogenetics along with other polyploids.

TOBACCO (*Nicotiana spp.*)

Breeding for high nicotine content was continued in *N. rustica*. The F_0 progeny of the intervarietal crosses was grown and 18 single plants were selected on the basis of growth, leaf size, leaf colour, leaf puckering and maturity. The preliminary yield trial with the 5 hybrids was repeated in 6 replications, each of 11 rows and 10 plants each. Besides the characters mentioned above, observations were taken on number of leaves per plant and yield of dry leaf. Three hybrids appeared superior to the control, N.P. 18, particularly in respect of yield, leaf colour and leaf puckering. Analysis for nicotine content of these selections is in progress in co-operation with the Divisions of Chemistry and Entomology.

PIGEON PEA (*Cajanus cajan.*)

Wilt resistance tests with 63 cultures including 11 N.P. types were continued in collaboration with the Division of Mycology. As in the previous years, cultures C 15, C 38, and D 16-17-2 proved highly resistant. Out of 22 cultures bred from the cross between N.P. 69 and N.P. 132 for wilt resistance and early maturity, seven cultures were

absolutely free from infection and six were slightly infected. From the Burma collection, New Era 40-6 was free from infection as in the previous year. On the basis of these results and on the observations on maturity and other important characters further selections have been made.

LINSEED (*Linum usitatissimum*.)

The testing and selection of strains for rust (*Melampsora lini*) resistance was continued at Delhi and Karnal. At Delhi 101 strains were tested with the help of the Division of Mycology for seedling and adult resistance with inoculation of the 4 physiologic races so far recorded in India. The adult resistance tests showed that out of 101 strains tested 79 were free from infection, 6 had slight infection and 16 had moderate infection. The control, N.P. 21 and the N.P. types used as parents, as also those under distribution were practically wiped out. The foreign varieties used as parents in the breeding investigation were quite free from infection.

At Karnal under conditions of natural infection, where the incidence of disease was heavy, out of 100 strains grown, 84 including all the 79 strains which were free from infection at Delhi, were free from infection. The control N.P.21, the N.P. parents and the types under distribution were infected to various extent, the foreign varieties used as parents remaining free from infection.

Selection work for early maturity, rust resistance and other economically important characters was continued in the F_3 progenies of crosses between very early Bengal types and some rust resistant strains which are late in maturity.

CHILLI (*Capsicum annum*.)

Further selections were made in the progenies of the cross between an Indian variety and a Hungarian type. Some of the selections are promising and will be tested for their field performance at 2 or 3 places in the next season.

SAFFLOWER (*Carthamus tinctorius*.)

The work on the isolation of the wild safflower types (*C. oxyacantha*) undertaken with a view to utilizing them in breeding was continued.

BROAD BEAN (*Vicia faba*.)

Further selections were made for early setting, large fruits and good bearing in the F_4 progenies of crosses between Broad bean and *Raharia seem*.

TOMATO (*Lycopersicon esculentum*.)

The promising selections from the cross *L. esculentum* $\times$ *L. pimpinellifolium* were given a further trial. Some of the selections are distinctly superior to the commercial varieties as they possess early maturity, good yield, high vitamin content and fine flavour. One of the selections contained vitamin C content as high as 63.6 mg. per 100 gm. of material, which is about the double of the commercial varieties examined. Small size of the fruit was observed to be correlated with fine flavour and high vitamin content. A report from a fruit-mart in New Delhi where the fruits were exhibited for sale, indicated that the fruits were in good demand even though sold at a higher price particularly because of their flavour, and the small size of the fruits was in no way a handicap against their popularity. Observations on maturity, yield, vitamin content, fruit size and

flavour for some of the commercial varieties, the wild parent and the promising selections have been summarised in the following table:—

Variety			Maturity (average number of days from sowing)	Average yield per plant in lb. oz.		Vitamin C content (mg. per 100 gm. of material)	Fruit size	Flavour
<i>L. esculentum</i>								
Earliana	...	...	112.5	4	4	27.1	large	acidic
Bengal 6	...	...	120.5	4	3	38.3	large	acidic
<i>L. Pimpinellifolium</i>	...	...	82.0	...	...	70.0	Very small	sub-acid
Selections								
T.S. 4	...	...	110.0	8	5	22.2	large	sub-acid
T.S. 12	...	...	90.0	2	2	63.6	small	rather sweet
T.S. 16-3	...	...	100.0	4	12	32.5	small	sweetish
T.S. 19-8	...	...	95.5	4	9	37.2	small	sweetish
T.S. 21	...	...	90.0	5	3	32.8	medium	sub-acid
T.S. 22	...	...	95.0	6	1	...	medium	sub-acid
T.S. 28	...	...	95.0	4	14	39.6	medium	sub-acid

For further improvement in earliness, vitamin content and flavour, etc., several crosses amongst the more promising selections were studied in the F_2 generation. Some of the selected plants from the F_2 progenies contained high vitamin content and also possess other useful characters.

It has been found that some of the new strains can be sown as early as June and still give a fairly satisfactory crop at a time of the year when the ordinary commercial varieties cannot be successfully grown.

EGG-PLANT (*Solanum melongena*.)

Further selections were made in the progenies of the crosses *S. melongena* $\times$ *S. incanum* and *S. xanthocarpum* $\times$ *S. melongena*. These selections are now almost free from the bitterness characteristic of the wild parents.

LADY'S FINGER (*Hibiscus esculentus*.)

The F_2 seeds obtained from the cross *H. esculentus* and *H. tetraphyllus* which apparently looked normal were found empty. No F_2 progenies could, therefore, be studied. New crosses were attempted in different combinations among *H. esculentus*, *H. tetraphyllus*, *H. ficulnius*, *H. pungens* and an unidentified species the fruits of which showed freedom from attack from borers and possessed a very thick pericarp. A collection of commercial varieties of *H. esculentus* was under study with a view to evaluating the more promising ones for utilization in breeding.

3. Study of hybrid vigour and the possibility of its exploitation in Agriculture

(i) *Maize (Zea mays)*. Experiments on inbreeding, hybrid vigour and improvements of methods of hybrid seed production were continued under the scheme for the improvement of maize crop in India financed by the Indian Council of Agricultural Research.

An all-India collection consisting of 209 varieties was studied with regard to important botanical and agronomical characters. Suitable varieties were selected for the production of inbred lines. Some of the white-seeded varieties from Hyderabad (Hyderabad State) were observed to be very early, maturing in about 60 days. Nineteen new exotic varieties, most from the United States of America, were added to the collection and studied to evaluate their breeding possibilities.

Work on the selection of suitable single and double-crosses was continued and the more promising combinations noted for further trials.

Arrangements were in progress to procure from Australia seeds of four double-crosses, viz., D.C. 462, 624, 716 and 724 for trials in the main maize-growing tracts of the country. These crosses were observed to do well at Delhi also in the previous years.

In other experiments on testing the comparative merits of selfing and sib-mating, extent of homozygosity required, convergent improvement, etc., selfing and crossing were done according to the programme.

Suitable selections were made from the F_2 progeny of the cross between maize and teosinte (*Euchlaena mexicana*) mainly from the fodder point of view.

(ii) *Causes of hybrid vigour*. Work was continued in connection with finding out the scientific basis of heterosis in plants. Suitable crosses made in sesamum, brinjal and tobacco were under study for the purpose. Reciprocal differences in the vigour of the most of the morphological characters were observed in the F_1 progenies of 2 varieties of tobacco, Ambalaema $\times$ Bonhrie and its reciprocal.

4. Other genetical investigations

(i) *Inheritance of sex forms in Luffa (Luffa acutangula)*. Observations on the crosses made between the three sex forms, namely, hermaphrodite, monoecious and andromonoecious, revealed that two pairs of factors were involved in the inheritance of sex forms in the various crosses. These results also suggested that two gene loci each with a multiple allelomorphic series (A-a1-a and G-g1-g) were concerned in the inheritance of the sex forms in Luffa. The various possible sex forms were thus tentatively designated as:

Monœcious AG, Andromonœcious a'G, Androœcious aG, Gynomonœcious Ag', Gynœcious Ag and Hermaphrodite ag, a'g', a'g and ag'.

(ii) *'Male-sterile' mutant in tomato*. The F_1 progeny of the cross normal $\times$ 'male sterile' mutant with thick leaves was normal in leaf character and fertility showing dominance of the normal condition.

(iii) *Extra glume, branched ear and glume colour in wheat*. Observations on the inheritance of these characters were continued in the progeny of the crosses *T. vulgare* $\times$ *T. vavilovi* and *T. vavilovi* $\times$ *T. sphaerococcum*.

(iv) *Sepaloid mutant in pigeon pea*. Observations on the segregating progenies from the cross normal (trifoliate leaf and normal flowers) $\times$ mutant (simple leaved and sepaloid) indicated that a single gene is responsible for determining the type of leaf and floral character. In a few sepaloid plants one or two normal flowers which set were observed towards the end of the season. The plants from these seeds will be studied next year.

CYTOGENETICS

1. The Oleiferous Brassicae

(i) *Classification*. The all-India collection of the cultivated *Brassicae*, which has been classified in this Division on a cytotaxonomic basis, and other related wild species comprising in all 384 cultures was maintained.

(ii) *Inbreeding*. Inbred progenies of a few diploid types of *toria* (*B. campestris* var. *toria*) and *sarson* (*B. campestris* var. *sarson*) were under observation and notes on their morphological characters were recorded. Continuous inbreeding for a number of generations was found to result in stunted habit, loss of vigour and reduced growth. Probably due to this effect, further inbreeding failed to give any seed.

(iii) *Genetical studies*. (a) *The 'dyad' mutant*.—The F_2 progeny of the cross tetraploid *toria* $\times$ 'dyad' mutant was under observation to study the inheritance of the 'dyad' character. Out of 296 plants observed for the sporad stage only 2 plants were found to form 'dyad' pollens to the extent of only 2 to 4 per cent. This suggested the possibility that the F_1 progeny was matromorphic. The study will be continued.

(b) *The male-sterile mutant in toria*.—Further crosses were made to confirm if the male-sterile character was governed by a two-factor difference.

(c) *The male-sterile mutant in taramira (Eruca sativa)*.—Observations on the F_2 progeny of the cross normal $\times$ male-sterile indicated that the mutant character was determined by a single gene.

(d) *Self-sterility in taramira*.—The study of the inheritance of self-sterility was continued. On the basis of crossability, the population has been classified into compatible, incompatible and intermediate groups and plants in each group were further crossed *inter se* for finding out the total number of sterility factors in this species. A few self-compatible plants have been observed and these were selfed for further study.

(iv) *Artificial induction and study of Polyploids*.—Large progenies both from single plant selections and crosses in the colchicine-induced autotetraploids of the several species of *Brassica* under study were grown and studied with special reference to morphological characters and fertility. As in the previous years, plants with high seed-fertility and having such other useful characters as profuse branching, early maturity, etc., were selected for further observations. In *toria* nearly 10,000 plants were under observation for habit, growth, vigour, maturity, pollen and seed fertility and characters of siliquae and 284 plants were carried forward for further study. Observations on seed fertility in the tetraploid *toria* indicated that as a result of continuous selection, there was an increase in the frequency of plants with high fertility in the entire population. In general, when cultures were considered individually, the average fertility was varying and in a majority of cases the average fertility of the plants was lower than that of its parent. But there were cases in which the maximum fertility of the plant was higher than the fertility of the parental plant or its culture. Such plants have been selected and further selection work will be concentrated on their progenies.

The data collected in connection with the study of the causes of sterility in autotetraploid *B. campestris* with special reference to cytological features were analysed and no significant difference in respect of the cytological behaviour was found in the progeny of the inbred, open-pollinated and double-cross, although the fertility of the inbred line was much less than the other two. Cytological behaviour did not thus appear to have any direct bearing on the degree of fertility in the autotetraploid. The fertility of the open-pollinated and double-cross progenies was, however, nearly the same.

In tetraploid *toria*, plants from cultures exhibiting desirable characters were crossed *inter se*. Crosses were also carried out to bring about combination of several desirable characters.

Preliminary observation on the breeding behaviour of the chromosome number in *taramira* indicated that the progeny of a tetraploid was composed of tetraploids, triploids, diploids and aneuploids. A number of crosses between different ploidy were,

therefore, made with a view to evaluating the nature and causes of reversion of the tetraploid to the diploid. Group crosses among tetraploid were also made to study the progenies.

In *Eruca sativa* the cytology of the following are being studied—triploid, diploid, tetraploid and aneuploids.

Crosses were carried out amongst the tetraploids of the different *Brassica* spp. and *Eruca sativa* to investigate the possibility of getting amphidiploids directly.

2. Fundamental Cytogenetical Research

(i) *Colchicine-induced ploidyploids of crop plants.* (a) *Chilli*.—The C_{10} progenies of autotetraploids of the type N.P. 51 and the C_3 progenies of autotetraploids of four other types were grown along with their corresponding diploids and studied with reference to fruiting ability, fruit size and seed setting. Suitable plants have been selected for further study.

Intervarietal tetraploid crosses were repeated as in the previous year. Seeds could not be obtained from such crosses due to unfavourable weather conditions. Good seeds have now been obtained. The F_1 seedlings will be raised and the effect of hybridity on sterility will be studied.

The few fruits set on the asynaptic plants have been harvested separately and data recorded regarding the number of seeds per fruits, fruit size, seed weight etc. These will be sown this season to study the nature of functional gametes.

The cytological study of the male-sterile, and the 'triploid' plants is in progress.

(b) *Gram*.—The C_9 progenies of autotetraploid of the type N.P. 25 were grown and further selection made. Seeds harvested from single plants of previous year were classed as bold seeds and shrivelled seeds and these were sown separately. These gave rise to tetraploids. A number of plants in a culture were examined for chromosome number and were found to breed true to number.

(c) *Sesamum*.—The A_6 generation of the amphidiploid *Sesamum orientale* ($2n=26$) $\times$ *Sesamum prostratum* ($2n=32$) was grown and studied with regard to breeding behaviour. As in the previous years, in this population about 6% of the plants were sterile and resembled the original F_1 hybrid between *S. orientale* $\times$ *S. prostratum*. These have evidently arisen through haploid parthenogenesis in the amphidiploid.

(ii) *Tetraploid Nicotiana glauca*.—The tetraploid of *N. glauca* obtained in the previous year as a result of grafting the scion of tomato (*Lycopersicon esculentum*) on the former and subsequent decapitation was grown and studied with reference to growth, size of leaf and stomata. The tetraploids were observed to be shorter in height than the diploids, the number of leaves on them was less, and their leaves were as long as the diploid leaf, but much broader. The gigantism generally associated with tetraploidy was not evident in the tetraploid of *N. glauca*. The pollen grain and stomatal size were, however, bigger in the tetraploid.

(iii) *Collection and study of wild relatives of crop plants*.—The collection of wild and allied species and genera of crop plants was maintained as in the previous years. A few forms among these have been used in hybridization and the progress made in this connection is indicated below.

(a) *Sesamum orientale* $\times$ *S. prostratum*.—Work on the utilization of the wild Indian species, *S. prostratum* ($2n=32$) for breeding economic strains of *til*, *S. orientale* ($2n=26$), resistant to phyllody and to the caterpillar pest, *Antigastra catalaunalis*, was continued.

The cytology of the triploid hybrid, $2n=42$, obtained by back-crossing the amphidiploid, *S. indicatum* ($2n=58$), to *S. orientale*, was further studied and the Drosera type of chromosome pairing, $13II-16I$ was confirmed. A few trivalents were, however, observed at diakinesis and metaphase I in some pollen mother cells. A number of plants in the progeny of the triploid and also in the reciprocal cross *S. orientale* $\times$ triploid were examined for chromosome number and pollen fertility etc. While in a majority of the plants the chromosome number was $2n=26$, few plants with $2n=26+1$ were identified and these extra chromosome-plants showed pollen of variable size or a little amount of pollen sterility or sometime both. Though a majority of plants greatly resembled *S. orientale*, there was evidence of the transference of some characters from the wild parent. Capsular and seed colour characters was some of the visual evidence for such transference.

In the progeny of the cross *S. orientale* $\times$ triploid, a haploid plant was obtained. It resembled *S. orientale* excepting that it was a diminutive form. Haploid in *Sesamum* has not been reported before. The haploid plant was completely sterile.

(b) *Sesamum laciniatum*.—The chromosome number of this wild Indian species was confirmed to be $2n=32$ from a study of root mitosis. A note embodying these results was published in 'Nature'.

(c) *Sesamum radiatum* $\times$ *S. orientale*.—Embryological studies were undertaken in the parents and the cross with a view to finding out factors responsible for the failure of the cross. In both *S. orientale* and *S. radiatum* fertilization and embryo and endosperm development were normal, except that in the latter the rate of growth was slower than the former. In *S. orientale* $\times$ *S. radiatum* a few ovules received pollen tubes 12 hours after pollination and the fertilization took place 12 hours after that; the endosperm had divided into a few cells by that time. It however showed the first sign of abnormality 48 hours after pollination when its cells appeared shrivelled. Seventy-two hours after pollination the embryo underwent its first division but the endosperm had shrivelled still more by that time. Twenty-four hours after that the embryo underwent another division and the disintegration of the endosperm continued. One hundred and twenty hours after pollination the embryo sac cavity contained a few collapsed cells and no embryo was visible. From this it would be clear that the death of the hybrid embryo in *S. orientale* $\times$ *S. radiatum* was due to disintegration of the endosperm which was responsible for the nutrition of the young embryo.

The reciprocal cross *S. radiatum* $\times$ *S. orientale* is under study and preliminary observations indicate that the hybrid embryo in the reciprocal cross meets with a similar fate and it dies much earlier.

PLANT PHYSIOLOGY

1. Drought resistance studies with wheat

(i) *Comparative study of ten varieties of wheat*.—There were ten pots (12" diam.) under each variety, eight plants per pot. About a fortnight after sowing when the seedlings were well established half the number of pots under each variety were subjected to intermittent drought, watering being withheld until the leaves just showed signs of wilting. At this stage soil moisture was reduced to about 4%. The soil moisture in the controls was maintained round about 15%. Observations on tillering, time of ear emergence, spikelet number per ear, grain number per spikelet, 1,000 grain weight and grain yield were recorded.

The order in which the varieties stood as regards grain yield is indicated below :

Control series			Drought series				
Variety	Mean Number of days from sowing to anthesis.	Significant differences	Variety	Mean number of days from sowing to anthesis.	Significant differences.		
N. P. 165	98	N. P. 165	> N. P. 52	N. P. 710	103	N. P. 52	> N. P. 165
Baluchistan 16		" "	> CPH 47	N. P. 52	103	" "	> CPH. 47
		" "	> N.P. 710	CPH. 47	109	" "	> Agra local
Agra local	107	" "	> C. 228	C. 228	106	N. P. 710	> -do-
C. 228	100	Baluchistan 16		Baluchistan 16	103	CPH. 47	> -do-
		" "	> N. P. 52				
Punjab 9D	105	" "	> CPH. 47				
N. P. 710	100	" "	> N. P. 710	Punjab 9D	107		
N. P. 52	97			N. P. 165	104		
CPH 47	108			Agra local	110		
S. 40 (Durum)	142			S. 40	143		
N. P. 735	147			N. P. 735	146		

Since two out of these ten varieties, viz., S. 40 and N.P. 735, were late and their grain yield was likely to suffer due to high temperature and low humidity prevailing at the time of ripening the first eight varieties are considered together first.

It appeared that varieties whose yields were of a lower order in the control series suffered less under drought and also yielded more. N.P. 52, N.P. 710 and C.P.H. 47 not only suffered less in yield as a result of intermittent drought as compared to N.P. 165, C228 and Agra Local but also yielded more than the last three. Thus N.P. 52, N.P. 710 and C.P.H. 47 may be regarded as relatively drought resistant as well as more useful from the practical point of view of yield.

A study of plant characters in relation to yield, in the control series, indicated a significantly positive correlation between yield and ear number only ($r = +0.7147$). There did not appear any relationship between maximum tiller number and ear number at harvest. In N.P. 52, which produced the greatest number of tillers, only 46% eared, while Agra Local which produced the smallest number of tillers had a ear tiller ratio of 86%. N.P. 165 was significantly superior to N.P. 52, C.P.H. 47, N.P. 710 and C.228

in respect of both yield and ear tiller ratio but not in respect of maximum tiller number. Nor was maximum tiller number in N.P. 165 attained at earlier date.

It would seem worth investigating the physiological factors responsible for this differential behaviour.

Considering grain size (1,000 grain weight) Baluchistan 16 and C.228 were superior to all other varieties. N.P. 165 was superior only to N.P. 52, C.P.H. 47 and Agra Local. There was little difference between N.P. 165 and N.P. 52 in regard to vegetative period and time of anthesis. What factor contributed to the difference in grain size?

In the drought series, only grain number per spikelet appeared to be correlated with grain yield ($r = +0.944$). Either fertility was adversely affected in some way by water strain or the processes concerned with grain filling were affected which reduced the number of grains filled per spikelet. A study of the physiological activity of the spike in relation to its water content under these conditions is indicated. Considering grain size, N.P. 52 was inferior to N.P. 165 and C.228 although anthesis occurred about the same time. N.P. 52, however, outyielded N.P. 165 and C.228 by virtue of higher grain number per spikelet. N.P. 52 outyielded Agra local also for the same reason. The same relationships hold substantively for N.P. 710 and C.P.H. 47. Considering the two late varieties, S. 40 yielded better than N.P. 735 in the control series and just as much as the later under drought. Their yields, both in the control and the drought series, were much inferior to those of the other varieties. The yield of S. 40 was low in the control series due to reduction in the number of grains per spikelet and in the number of ears. That of N.P. 735 was low due to reduction in the number of grains per spikelet and in grain size. In the drought series the yields of both these varieties were the lowest because of reduction in the number of grains per spikelet and in ear number. The thousand grain weight in S. 40 in the control series was as good as that of the other early varieties, whereas that of N.P. 735 was half as much. The grain size did not diminish due to drought in both the varieties.

(ii) *Comparative study of the assimilatory capacity of the ear of five varieties.*—Since it has been estimated that about one quarter to one third of the total dry matter of the grain contributed by the assimilatory activity of the ear, it implies that the environmental conditions after ear emergence would have considerable influence on yield. It was, therefore, thought worthwhile to investigate whether there was any varietal difference in respect of contribution by the ear to grain weight. The estimate of this contribution by the ear was made in an indirect way by cutting out light round about the ear soon after anthesis and thus preventing it from assimilating. This was achieved by enclosing the ear in double walled paper chambers of suitable size with their inner walls darkened. Ventilation was provided by small holes in the walls of the chamber. The holes in the inner wall of the chamber did not coincide with those in the outer and thus infiltration of light was effectively checked. Four treatments were included in this experiment: (1) control; (2) ear shaded; (3) green leaves removed (4) ear shaded and green leaves removed. Eight more or less uniform shoots per pot (12" diam.) were taken and the four treatments were randomized among these. Ten such pots were taken for each variety. The treatments commenced soon after the anthers dehisced. First plant sample was taken when the treatments commenced and this gave an estimate of the total dry matter accumulated in the plant by the time of ear emergence, as well as its distribution in the different parts. At harvest observations were taken on grain weight per shoot, dry matter of different parts, 1,000 grain weight and number of grains per spikelet.

The mean percentage contribution to grain weight by assimilation in the ear is indicated below :

Due to	N. P. 710	N. P. 165	Punjab 95	Agra Local	N. P. 735
Ear shading	43.3 + 3.31	15.3 + 3.99	23.2 + 3.45	23.9 + 3.78	59.4 + 3.31

The contribution to grain weight by the assimilation of the ear was the highest in N.P. 735, followed by N.P. 710. N.P. 735 is a very late variety and therefore the other four varieties may be considered together. N.P. 710 differs substantially from the other three varieties in that 40% of its grain weight is contributed by the assimilation of the ear. It is tentatively suggested that the relatively greater drought resistance of N.P. 710, as noted in the previous section, may be due to the greater contribution by its ear to grain weight. The high assimilatory activity of the ear of N.P. 710 would offer this variety an advantage especially under conditions of water strain when the translocatory mechanism would probably be less active. The very high contribution by the ear to grain weight in the case of N.P. 735 is conceivably due to its late maturity. During the ripening period of its grain high temperature and low humidity prevailed which probably affected the translocation of the dry matter to the ear more than the assimilation by the ear.

(iii) A large-scale field trial of pre-treated seed of N.P. 4 wheat did not give any increased yield. The pre-treated seed is expected to fare better under 'barani' and since the last season was rather wet it is probable that the control seed did not suffer from lack of moisture.

2. Photoperiodism and Vernalization	...	} These items were not taken up during the year.
3. Studies on salt resistance in wheat	...	
4. Genetics of physiological characters	...	

5. Plant Hormones and chemical regulation of growth and development in plants

(i) *Study of diffusates from seeds of different varieties of wheat.*—Consequent upon the report by Bonner, Haagen-Smit and Went (1940) on the existence of leaf growth hormone in the diffusate from pea seed, it was thought interesting to examine if any such growth factor could be detected in seeds of different varieties of wheat. Since the rate of growth of the root of maize seedling was depressed by this diffusate the depression in the growth rate of root was taken as an indirect evidence of the presence of the growth factor. From the data in table it will be seen that diffusates from seeds of *T. vavilovi* and Khapli alone indicated the presence of an inhibiting substance in their seeds. No systematic relation was found between the length of the vegetative period of the varieties

and the presence of the inhibiting substance in their seeds. That this substance was of the nature of a hormone seemed to be indicated by the inward curvature developed by split wheat coleoptiles when dipped in the diffusate. Crushed wheat meal, when treated with alkali, has been found to release appreciable quantity of auxin, which occurs otherwise in a bound state. It appears likely that seeds of *Triticum vavilovi* and Khapli contain auxin in a free state, whereas others do not. It seemed worth investigating the significance of this difference between the varieties and a preliminary experiment was undertaken to see the performance of plants grown from ordinary seed and seed repeatedly extracted with water. Two varieties, viz., N.P. 165 and *T. vavilovi*, the former showing the absence of the factor and the latter its presence, were tested. No systematic difference due to this treatment in regard to general growth, vigour, or length of the vegetative period was noticed in either case.

(ii) *Pre-treatment of seed with Indolyl acetic acid.*—Wheat (N.P. 165 and *Triticum polonicum*, an early and a late variety respectively) seeds were soaked in 100 ppm indolyl acetic acid for about three hours and dried and the treatment was repeated thrice. These seeds were tested against two checks, viz., dry seeds and seeds soaked in water. None of the treatments induced earliness of flowering or influenced yields in any way.

(iii) *Influence of indolyl acetic acid spray on fruiting in tomatoes.*—The object was to see if fruiting was in any way promoted by this spray during August and September when the tomato plant is exposed to high temperature. Pruning to a single branch was also tried as another variant. The experiment was conducted in pots. Hybrid T.S. 19-1 was alone able to produce some fruit under these conditions when pruned. The spray had little effect.

(iv) *Effect of weedicide—Agroxone.*—From a wheat plot to which Agroxone was applied in a few strips (at the rate of 224 lb. to the acre) the total green weight of weeds collected was only 18 lb. (total area 180 sq. ft.) as against 45 lb. from untreated strips. It was not possible to try its effect on a large scale and estimate the economic benefit accruing from its use for want of sufficient amount.

6. Miscellaneous

(i) *Permanent wheat plot:* Only one variety, viz., N.P. 165, was included in the plot. Eighteen (weekly) samples of plants were collected during the season. Dry weights of different plant parts were determined and the samples were powdered and preserved for chemical analysis. Weekly soil moisture determinations were also made. The crop made good growth and yielded at harvest, per 0.1 acre, 877 lb. total dry matter and 3 md. 30 srs. grain. These yields are not corrected for removal of the crop for sampling (to the extent of about 3%).

(ii) Evidence upon the effect of fluorescein upon plant growth is conflicting although Sellei, Sellei, Meyer and Went (1942) have recently reported upon its favourable effect in very minute doses. In a preliminary experiment with wheat—N.P. 165 (6 pots per treatment and 6 plants per pot) fluorescein at the rate of 8 mg. per pot (containing about 12 lb. of soil) increased grain yield over the control by about 70 per cent. This increase was mainly due to the increase in the number of ear bearing tillers.

DATA ON THE EFFECT OF SEED DIFFUSATES FROM DIFFERENT VARIETIES OF WHEAT

Date	Dura- tion of the test in hours	No. of maize roots tested	Time in hours for ex- tract- ing wheat seeds	No. of wheat seeds extract- ed water for ex- tract- ing	Vol. in cc of water	Mean rate of growth of maize root in cm. in diffusates from different varieties of wheat seeds.									
						Control	T. vulg. N.P. 165	T. vulg. C.13	T. dico. Khapli	T. Pyra- midale	T. dic. mindum	T. du. Kubanka	T. per- sicum	T. polo- nicum	T. vavi- lovi
2/10/47	17.5	20	12	100	30	3.12 + 0.21	3.16 + 0.12	...	...	...	...	...	...	...	2.73 + 0.1
5/10/47	16.0	15	12	200	30	3.22 + 0.14	2.99 + 0.14	...	...	...	...	...	...	...	2.03 + 0.13
10/10/47	19.0	15	6	"	"	3.56 + 0.22	3.46 + 0.12	...	...	...	...	3.27 + 0.10	...	3.38 + 0.01	2.55 + 0.10
20/10/47	15.0	"	"	"	"	2.77 + 0.15	...	...	1.22 + 0.07	...	2.70 + 0.09	...	2.06 + 0.18	...	...
19/10/47	15.0	"	"	"	"	2.48 + 0.12	...	1.68 + 0.13	1.33 + 0.09	2.10 + 0.13	...	...	...	...	...
23/10/47	"	"	"	"	"	2.34 + 0.15	...	2.08 + 0.14	...	...	...	...	...	...	...

N.B.—Underlined figures are significant.

PLANT INTRODUCTION

1. Plant Exploration

Some of the places in Orissa were surveyed in connection with the collection of seeds of important indigenous wild plant material. The more important collections consisted of *Solanum* species (Orissa appears to be particularly rich in *Solanum* species and varieties), malvaceous plants such as *Hibiscus surratensis*, *Urena lobata*, *U. repanda*, *Sida* species, legumes such as *Crotalaria* species, *Cassia hirsuta*, *Dolichos falcatus*, *Rhynchosia bracteata*, *Indigofera pulchella*, *Desmodium biarticulatum*. A grass very closely resembling African love grass (*Eragrostis curvula*) was collected from the sandy coast near Puri. Seeds of the sand-binding plant, *Ipomea biloba*, were also collected.

2. Import of seed

Further seed samples, over two hundred, of a number of plants mostly of grasses and legumes and of new improved varieties of various crop plants and other plant breeding material, were obtained from various countries. The new imported varieties include rust resistant wheats from Australia, Kenya, U.S.A. and Canada; barleys with high malt-ing quality, varieties of leguminous crops such as soyabeans, peas, mung, beans, cow-peas, etc., from Philippines, China, etc., cruciferous vegetables such as radish, turnip, cabbage etc., from China. Varieties of safflower with high oil content from Nebraska, Russian oil yielding varieties of safflower from Montana, linseed varieties from Argentina were also obtained. A number of legumes, namely, tropical kudzu, clovers such as *Medicago orbicularis*, *M. hispida*, *Melilotus alba* var. evergreen, *Trifolium repens*, *Melilotus officinalis* (yellow sweet clover, and vetches (*Vicia sativa* and *V. hirsuta*) were obtained from U.S.A. Among the grasses which may be useful for soil conservation, as fodders and for ley-farming mention may be made of Buffalo grass, Zoysia grass, Timothy, Red top, Kentucky Blue grass, Brome grass, Canary grass, Orchard grass, Napier grass, Dallis grass, Love grass, Crested wheat grass, Blue stem and Blue and Hairy grama etc., these were also obtained from foreign countries.

3. Living collection

A fairly large number of exotic and indigenous wild and cultivated plants were under observation. Some of the important observations are noted below.

Legumes.

Lespedeza: The perennial lespedeza from U.S.A. (*L. cuneata*=*L. sericea*) was compared with alfalfa (*Medicago sativa*) as regards growth, response to cutting etc. During the first year of growth lespedeza was slow as compared with alfalfa. In summer, however, lespedeza showed a more vigorous growth.

Kudzu: Tropical kudzu (*Pueraria phaseoloides*) and kudzu vine (*P. hirsuta*=*P. thumbergiana*). The tropical kudzu was highly susceptible to frost but in the spring new shoots appeared from the old root stocks. It has not flowered so far although the plants are now more than two years old. The kudzu vine grew more vigorously than the tropical kudzu.

Tephrosia candida, which is commonly used as green manure and cover crop, was found to grow well as a perennial under Delhi conditions.

Grasses.

African love grass: *Eragrostis curvula* and *E. curvula* var. *valida*. The two grasses, particularly the latter, appear to be promising as perennial grasses for fodders and for soil conservation.

Lehman love grass: *Eragrostis lehmanniana* (from U.S.A.). Although the growth was not very prolific, it appeared to be suitable for soil conservation.

Kikuyu grass: *Pennisetum clandestinum* (from Kenya). It is a slow growing grass with prostrate habit. The older branches were found to dry up during the hot weather.

Bahia grass: *Paspalum notatum*. It appears to be suitable for soil conservation.

Brome and canary grasses: *Bromus catharticus* and *Phalaris canariensis* (from U.S.A.). When grown as winter annuals the growth was fairly prolific. Flowering and seed setting were found to be normal.

Medicinal plants.

Licorice (Mulethi): *Glycyrrhiza glabra*. Delhi soil and climate appear to be very suitable for growing this important medicinal plant. The spread of the root system has been so quick that it has within a short period of two years become almost a pest. It might be worthwhile trying it on sandy waste lands in the different parts of the country.

Isabgol (Plantago ovata and P. psyllium): *P. ovata* was observed to be more suitable than *P. psyllium* (European isabgol) as it is early maturing, grows better under dry conditions and is superior in mucilaginous properties of the seeds.

Indian squill (Urginea indica). It was observed to grow wild at Delhi. It showed a very slow growth.

Other material.

A variety of spinach and a few varieties of radish obtained from China appeared promising in quality. *Urena lobata*, a wild fibre plant, appears to be worth investigating from fibre point of view.

4. Export of seed

Seeds of some of the new plants were supplied to Provincial Agricultural Departments and Institutions for trials. In this connection mention may be made of *Lespedeza sericea*, *Pueraria phaseoloides*, African love grass, *Cinchona* species, castor and Russian drought resistant rice.

III.—MISCELLANEOUS

CROP OUTTURN AND SEED DISTRIBUTION

The crop outturns of most of the crops were normal. There was no serious damage to any crop by pests and diseases. The multiplication of pedigree N.P. seeds was possible on a small scale only. As in previous years the demand for improved seeds far exceeded the supply. There was a heavy demand for N.P. wheats particularly of N.P. 52 of which some of the indentors offered to purchase as much seed as could be supplied. Only a small part of this demand could however be met. The seeds of the improved varieties were distributed mainly to the Provincial and State Departments of Agriculture.

ADVISORY

A large number of enquiries were received from all over the country and from abroad regarding refereeing of papers for publication, writing of reviews, exchange of seeds and

other material, methods of breeding and cultivation, economic wild and cultivated plants including identification of plant specimens etc., and the information asked for was supplied. The various advisory items may be classified as follows :

<i>Nature of enquiries</i>	<i>Number.</i>
1. Notes on particular topics and comments on papers and reports etc.	11
2. Vernacular and botanical names, methods of cultivation, sources of seed supply and other miscellaneous information	61
3. Seed samples received	30 sources.
4. Plant specimens identified	13
5. Seed samples supplied	13 correspondents.

Some of the more important advisory work is briefly summarised below :

1. In reference to a query made by the Government of India in the Ministry of Agriculture regarding the suitability of rust affected shrivelled wheat grains as seed, tests on germination and subsequent short time performance of the seedlings were carried out. It was reported that the shrivelled seed could be utilized as seed after making allowances for the germination capacity and reduced grain size in seed rate.

2. A comprehensive note on the *striga* parasite of sugarcane was furnished in connection with an enquiry from Sardar Datar Singh, Vice-Chairman, Indian Council of Agricultural Research.

3. The Government of India in the Ministry of Agriculture were supplied with information on the application of electro-culture.

4. Suggestions regarding the syllabus for the first year course of the Central College of Agriculture, Delhi were given to the Principal of the College.

5. Information concerning the culture of mustards in India were supplied to Mr. Hubert de Limirac, Consul for France, Bombay.

6. A list of publications regarding the commercial quality of minor oilseeds was supplied to the Agricultural Marketing Adviser to the Government of India.

7. Dr. J. C. Ghose, Director of Industries and Supplies, New Delhi, was supplied with a note on the 'Utilization of sea weeds' with special reference to plantations.

8. As in the previous year the Directorate of Inspection and Marketing, Ministry of Agriculture, were supplied with information, as far as possible, regarding the identity and poisonous properties, if any, of the weed seeds found in imported food grains.

9. Information was supplied and advice given to the Superintending Engineer, Delhi regarding the water requirements of different crops in the south-east Punjab and Rajutana.

IV.—PROGRAMME OF WORK (1948-49)

I. APPLIED GENETICS

I. Studies in the improvement of Indian wheat will be continued.

II. The work reported on breeding crop plants for disease resistance and other qualities will be continued.

III. Trials with the newly evolved strains of different crop plants in Provinces and States will be continued.

IV. The work on utilization of hybrid vigour for the improvement of Maize in India will be continued.

V. The genetical investigations reported will be continued.

II. CYTOGENETICS

I. Cytological investigations on the autotetraploids of crop plants like *Brassica*, *Eruca Capsicum*, *Sesamum* and *Cicer* with special reference to breeding.

II. Cytogenetical study of the progenies obtained from the interspecific cross *Sesamum orientale* $\times$ *S. prostratum* for isolation of progenies with desired characters (disease and pest resistance) from the wild parent.

III. Study of inheritance of self-sterility in *Eruca* and male sterility in *Capsicum*.

IV. Interspecific hybridization in *Linum*.

V. Cytogenetics of some interspecific and intergenetic hybrids in wheat.

III. PHYSIOLOGY

I. Studies on drought resistance will be continued.

II. Investigations on plant hormones and chemical regulation of growth and development will be continued.

III. Investigations on physiological analysis of factors influencing yield will be continued.

IV. Investigations on some aspects of mineral nutrition of wheat will be taken up.

IV. PLANT INTRODUCTION

I. Further areas will be surveyed in connection with collection and study of important indigenous plant material.

II. Attempts will be made to import more material from foreign countries and to study it from the point of view of its utilization in breeding or direct introduction.

III. The existing collection will be maintained and further studied.

IV. Survey of literature for compiling information on economic plants.

Report of the Sugarcane Expert, Coimbatore

I.—INTRODUCTORY

During the greater part of this year the services of the Second Cane Breeding Officer, Dr. N. Parthasarathy and of the Plant Physiologist, Mr. N. D. Yusuf were not available to the Station as the former was relieved to join as Geneticist at New Delhi and the latter for proceeding to Pakistan. The Botanist of the *Spontaneum* Expedition has not yet been appointed, but the Assistant Botanist, Mr. S. K. Mukherjee has made collections of the wild forms of *Saccharum* and allied grasses from the forest areas of South India. Mr. K. V. Gopala Iyer was appointed during the year as Chemist (Class II) in the Scheme of Additional Staff.

II.—SUGARCANE BREEDING

(a) Hybridisation and Selection

The weather during the year was the driest on record and the rainfall during the flowering season was only 40% of the average for the last twenty years. Excepting three varieties viz., Co. 543, Co. 620 and Co. 622 which did not flower and could not be utilised for breeding, the rest of the programmed crosses were carried out fairly normally. In all 102 crosses were effected in addition to about 250 crosses and selfs for genetical studies.

(i) *Bulk and semi-bulk scale economic crosses.*—The four varieties, Co. 449, Co. 527, Co. 534 and Co. 617 were exploited fully for raising seedlings on a bulk scale, since these have been found to give desired type of seedlings as judged from the experimental crosses done during the last two years. Co. 449 and Co. 527 yield early maturing seedlings while Co. 534 (Co. 349 × Co. 312) has now replaced Co. 349 as a parent for new crosses as it gives better seedlings than Co. 349. Another cane which is figuring as a parent in the recent crosses is Co. 617 which imparts good vigour to its progeny. It has replaced Co. 285 as a parent for introducing vigour in the seedlings. Fourteen crosses on a bulk scale and twenty on a semi-bulk scale were done, the more important ones being:—(1) Co. 508 × Co. 449, (2) Co. 508 × Co. 453, (3) Co. 508 × Co. 545, (4) Co. 508 × Co. 617, (5) Co. 534 × Co. 285, (6) Co. 534 × Co. 453, (7) Co. 527 × Co. 285, (8) Co. 527 × Co. 453, (9) Co. 527 × Co. 617, (10) P.O.J. 2878 × Co. 449 and (11) Co. 449 × S.G. 63/32. Combinations with Co. 508 generally yield rich early type of seedlings. The usefulness of this variety for the production of rich seedlings can be judged from the fact that as many as six Co. canes sent out this year were of Co. 508 parentage.

(ii) *Experimental crosses for evaluation of parents.*—Two of the recent releases, Co. 638 and Co. 644 have been used in many experimental crosses to evaluate the nature of seedlings obtained from them. Co. 638 is an early cane with a competitive tonnage. Co. 644 combines in itself the qualities of richness of juice and yield. Co. 475, a cane essentially for tropical India and which competes well with Co. 419 in Bombay Province was utilised in four experimental crosses.

(iii) *Sorghum crosses.*—The sorghum hybrid Co. 630 (P.O.J. 2878 × Sorghum Durra, Stapf) was utilised in two bulk and two semi-bulk crosses. A study of the seedlings of the crosses effected during the previous years shows that they are poor in growth and tillering

and the sucrose content not above average. This variety is being discarded from the list of parents. Co. 639 (S.C. 851 $\times$ Co. 331) also does not give promising seedlings. Two of the sweet sorghums were utilised in the experimental crosses.

(iv) *Bamboo crosses*.—It would be desirable to repeat this cross as none of the seedlings from the previous crosses are promising. Flowering bamboo clumps have been secured and will be utilised in the ensuing flowering season.

(v) *Fodder crosses*.—The following seven crosses were effected with Napier grass (*Penisetum purpureum*) as the female parent; (1) Napier grass $\times$ Co. 285, (2) Napier grass $\times$ Guinea grass (*Panicum maximum*) (3) Napier grass $\times$ *Sorghum halepense* (Humpi), (4) Napier grass $\times$ G. 1051, (5) Napier grass $\times$ *Narenga porphyrocoma*, (6) Napier grass $\times$ *S. spontaneum*, (Coimbatore) and (7) Napier grass $\times$ G. 6331 (*Sorghum halepense* $\times$ Guinea grass). These are all inter-generic crosses. The seedlings are at present young and it will take some more time before their flowers emerge. They, however, all look so much alike and are so similar to Napier grass in vegetative characters that it is very difficult to say if the cross has been genuinely effected. It is felt that in inter-generic crosses care should be taken first to ascertain whether the seedlings in question are not parthenogenetic in origin before pronouncing them as genuine inter-generic crosses. These seedlings are therefore being kept under further observation. It may be stated that care was taken to effect only bagged crosses and one advantage with Napier grass is that it is protogynous. There is, therefore, no possibility of the seedlings having resulted from self pollen.

(vi) *Crosses for evolving chewing types*.—Two of the soft rinded varieties, Co. 603, and B. 6308 were utilised in experimental crosses for the production of chewing canes. The crosses are (1) Co. 603 $\times$ P. 4628, (2) B. 6308 $\times$ P. 4628, (3) B. 6308 $\times$ Co. 449 and (4) B. 6308 $\times$ POJ. 2878.

(vii) *Nursery seedlings*.—Germination in the pans was satisfactory. Good germination was recorded in the following crosses:—(1) Co. 508 $\times$ Co. 453, (2) Co. 508 $\times$ Co. 617, (3) POJ. 2878 $\times$ Co. 545, (4) Co. 534 $\times$ Co. 453 and (5) G. 4938 $\times$ Co. 453.

There were 18,000 seedlings in the Second Ground Nursery. From among the crosses, the following combinations gave the desired type of seedlings and are worth repetition; (1) Co. 534 $\times$ Co. 453, (2) Co. 421 $\times$ Co. 617, (3) Co. 508 $\times$ Co. 313, (4) Co. 508 $\times$ Co. 453, (5) P. 2607 $\times$ Co. 644 and (6) P. 4626 $\times$ Co. 644. The first mentioned cross is good from both sucrose and tillering points of view. The seedlings are vigorous and the canes medium in thickness. Seedlings of the cross Co. 421 $\times$ Co. 617 are on the thinner side but with good tillering and fair sucrose. The seedlings of Co. 508 though always short and thin are rich in sucrose and good in tillering, while those of Co. 644 are rich and early with good vigour and tillering.

(viii) *Test plots*.—From the above nursery plot, 790 seedlings were selected for trial in the preliminary test plot, which was laid out in the form of randomised blocks. The area at the Station is limited and the replications have been done at the expense of other rotational crops.

From the 1947-48 preliminary plot, 228 seedlings out of a total of 1,000 were selected for promotion to final trial. The final trial plot was also laid out in randomised blocks. The following crosses were noticed to give the desired economic types of seedlings:— (1) Co. 270 $\times$ Co. 301, (2) Co. 464 $\times$ Co. 301, (3) Co. 464 $\times$ Co. 453, (4) POJ. 2878 $\times$ Co. 371 and (5) P.O.J. 2878 $\times$ Co. 453. The best among these was the cross Co. 270 $\times$ Co. 301 which gave seedlings of good tillering and juice quality as also of a non pithy core.

In last year's final plot, 173 seedlings were under trial. Out of these thirty were raised to the status of Co. canes. Their parentages and general characteristics are given elsewhere in this report.

III.—INVESTIGATIONS

(a) Breeding Technique

(i) *Seed pans*.—For the sowing of sugarcane seeds, local countrymade earthenware pans have all along been employed at the Station mainly from the point of view of cheapness. But these pans are so ununiform that great variation in germination and vigour of seedlings even from the same parentage is observed and thus the samples of seedlings are not strictly comparable. It was thought, therefore, that in the case of valuable genetical material, it would be desirable to employ glazed uniform pottery. An experiment was conducted to compare the percentage of seed germination and the mortality of the seedlings in the earthenware pans as against glazed pans. Seeds from two different crosses, *viz.*, (1) Co. 464 $\times$ Co. 617 and (2) Co. 453 $\times$ Co. 557 were taken. In regard to the percentage of germination, the germinations are slightly higher in the glazed pans but not significant. The mortality rate of the seedlings is less in the glazed pans and the difference is significant at 5% level in the cross Co. 453 $\times$ Co. 557 and also if both the crosses are taken together. The greatest difference, however, is in the vigour and uniform growth of the seedlings. It was also noticed that in the earthenware seed pans, the roots tend to come out of the mass of soil while in the glazed pans they are not visible outside. The contrast in the health and vigour of the seedlings is so striking and is so much in favour of the glazed pans that it has been decided to substitute glazed pans for the earthenware pans.

(ii) *First Ground Nursery*.—From the seed pans, the seedlings are removed to the Ground Nursery in which they are spaced 6" apart. In this Nursery (which is called the First Ground Nursery) the seedlings remain for 3 to 4 months when they attain a height of about three feet, and have again to be transplanted into the Second Ground Nursery where the spacing is about two feet either way. No special extra manuring is given in the First Ground Nursery stage apart from the basic farm yard manuring while preparing the land. An experiment was laid out to see, if, by extra manuring greater number of economic seedlings will be available for selection. The levels of manuring used were 0 lbs., 40 lbs. and 80 lbs. nitrogen per acre. It is proposed to watch the seedlings through all the stages of selection, *viz.*, to the final test plot. Two crosses have been taken for this experiment (1) Co. 508 $\times$ Co. 617 and (2) Co. 527 $\times$ Co. 453.

(iii) *Second Ground Nursery*.—The Second Ground Nursery represents the final Nursery stage in which the seedlings (with about 2 feet spacing either way) remain for one full year. It is from this Nursery that seedlings are selected for further vegetative multiplication and promotion to trial plots. The selection is based on growth (including tillering) and habit characters as also on brix. The selection is rather rigorous and the result is that seedlings with only 5 or 6 tillers, even though fairly vigorous are often rejected and only clumps having more than 6 tillers and fairly good growth and brix stand a chance of selection. The average annual number of selections come to only about 3% of the total population (and thus more than 90% of the seedlings are rejected). Of course one reason for this ruthless rejection is the limitation of land but it was thought worthwhile to try an experiment by taking the Second Ground Nursery seedlings at random irrespective of growth and tillering and subject them to different levels of fertility. "The object of the experiments is to ascertain varietal responses to different levels of fertility with a view to selection of suitable types for such levels." Four crosses were taken for this experiment (1) Co. 534 $\times$ Co. 453, (2) Co. 421 $\times$ Co. 617, (3) Co. 508 $\times$ Co. 453 and (4) P.O.J. 2878 $\times$ Co. 453. Seedlings possessing three tillers and above upto twenty four tillers were selected at random and have been given the following four

treatments (1) 50 lbs. N. and restricted irrigation (30 days); (2) 50 lbs. N. and normal irrigation (10 days); (3) 100 lbs. N. and normal irrigation and (4) 150 lbs. N and normal irrigation. It is proposed to take all these seedlings through the usual stages of trial adopted for seedlings.

(b) Chemical Studies

(i) *Bimonthly plantings*.—With a view to finding the effect of different planting periods on the yield and quality of sugarcane varieties, a preliminary experiment was started at the Thick Cane Area, with the varieties Co. 419, Co. 421 and Co. 449. These were planted at bimonthly intervals in April, June, August, October, December and February. The periodical analyses of the canes were started when the crop was ten months old and continued till the seventeenth month. As regards the result it was found that the April planting was about the best with respect to early maturity, yield of cane and total C.C.S. per row. The following table gives the maximum yield of cane and total C.C.S. of the varieties planted at different periods.

TABLE I.

Period of planting.	Co. 419.		Co. 421		Co. 449.	
	Wt. of canes per row in lbs.	C. C. S. per row in lbs.	Wt. of canes per row in lbs.	C. C. S. per row in lbs.	Wt. of canes per row in lbs.	C. C. S. per row in lbs.
April	352.80 (17)	42.21	322.4 (14)	37.95	350.0 (17)	47.74
June	207.00 (15)	27.49	216.0 (17)	26.40	204.0 (17)	26.40
August	231.00 (17)	25.72	108.0 (15)	13.87	158.4 (16)	20.29
October	93.60 (17)	11.23	165.0 (14)	20.18	145.6 (17)	19.85
December	162.00 (17)	17.79	140.6 (16)	16.46	204.0 (17)	22.84
February	271.40 (15)	34.31	212.8 (15)	23.57	217.8 (13)	29.06

The figures in brackets refer to the age of the crop in months.

The canes in April planting were mature in ten months in Co. 419 and Co. 421 and in eleven months in Co. 449. One interesting feature of this series was that though there was marked deterioration in juice quality of all the three varieties in the 14th and 15th months (June-July) all these three varieties showed remarkable recovery in juice quality in the 16th and 17th months and reached the peak values obtained earlier. In the case of Co. 449, the value of C.C.S. in the 17th month was even greater than the peak value reached earlier.

In the June, August and October plantings, the crop was very immature at the 10th month stage and reached maturity only in the 14th and 15th months. The yields in these three plantings were also poor.

In the December and February plantings, the canes like the April plantings reached maturity in the 10th month. From the point of view of yield the February planting was better than the others but not so good as April plantings. One other point which deserves mention is with regard to the variety Co. 449 and that is that it showed superior keeping quality in all the above plantings.

(ii) *Factory recoveries in Madras and Bombay Provinces.*—The Chemist made a tour of the more important sugar factories in Madras and Bombay to make observations on the manufacturing qualities of the canes crushed by the factories. He found that in the Madras factories, the recoveries were in general rather low though the milling and boiling house efficiencies were satisfactory. It is curious to note that Co. 419 and POJ. 2878 which gave recoveries of eleven per cent. and more in the Bombay factories, gave only nine per cent. recovery in the Madras factories. It was noticed that in the Bombay area use of Superphosphate in clarification was necessary with all the varieties because of the comparatively low P_2O_5 in the juice. The same varieties in the Madras area, on the other hand did not need any phosphate in clarification.

(c) Cytogenetical Studies

A study of the morphological characters with reference to the chromosome numbers of the various *Erianthus* types grown at the Station, shows that the *Ravennæ* group which is characterised by the presence of forms with narrow leaves has $2n=20$ chromosomes while both wide and narrow leaved forms exist among the higher polyploid types. It would appear to be possible that in nature simple diploid forms ($2n=20$) with wide leaves exist, and the higher polyploid forms with $2n=30$, $2n=40$ and $2n=60$ chromosomes have arisen as a result of hybridisation between the simple wide and narrow leaved types. Crosses have been effected among the different types and the progeny is being studied cytologically for chromosome analysis and classification.

The presence of an awned fourth glume in a few *S. Officinarum* types has been considered as a possible indication of the part played by *Erianthus* in the evolution of cultivated canes. A study of the F_1 progeny of the cross between *Narenga porphyrocoma* and *Sclerostachya fusca* showed the presence of an exerted awn in one of the seedlings, a feature characteristic of *Erianthus*. It would thus appear that the question of the origin of sugarcane is highly complicated and a detailed and critical study of the inter-relationships of the various genera has to be made.

It has been found that whenever *S. Officinarum* types are crossed with *S. Spontaneum* only unreduced gametes ($2n=80$) function on the *S. Officinarum* side. A few reciprocal crosses have been effected and suitable types have been selected for cytological study with a view to ascertaining the nature of the gametes that function in *S. Spontaneum*. In one of the seedlings, between *S. Spontaneum* (Coimbatore) and *Sorghum halepense* (Humpi) it was found that unreduced gamete ($2n=64$) had functioned, while in a seedling of the cross between *S. Spontaneum* and sweet *Sorghum* (S.H. 396), a reduced gamete ($2n=32$) was found to have functioned, indicating that *S. Spontaneum* also produces both unreduced and reduced female gametes.

It has been reported that *S. Officinarum* has two basic complements of $n=5$ and that one of them is common to *Sclerostachya*. With a view to ascertaining the homology of the other complement, crosses have been effected with other allied genera and suitable types have been selected for further cyto-genetical studies.

With a view to obtaining seedlings with a haploid complement of *S. Spontaneum* chromosome, systematic crosses and back-crosses with *S. Spontaneum* as the female parent and *S. Officinarum* as also other allied genera as male parents have been effected.

(d) Physiological Studies

Studies into the chemical composition of flowering and non-flowering cane varieties viz., Co.421 and Co.442 respectively with regard to their carbohydrates and nitrogen constituents, were continued and this completes the 3rd year of such analyses for these two varieties. The data confirm the results obtained in the previous two years viz., that there is no indication of any marked difference in the two varieties except in the soluble carbohydrate content and the total carbohydrate-nitrogen ratios. The soluble carbohydrates maintain a higher level throughout the growth period in the flowering variety Co.421 as compared to the non-flowering variety Co.442. The carbohydrate-nitrogen ratios are consistently higher in Co.421 as compared to Co.442. Starting with characteristically low values, the ratios in both gradually rise till the flowering period when it shows a rise in Co.421 while in Co.442 it remains more or less stationary.

"The physiological basis of flowering still remains to be fully ascertained. Though from the above it may seem that in a flowering variety the soluble carbohydrates are maintained at a higher level throughout the growth period, it may just be that it is so in the particular variety studied viz., Co.421 as it is richer in sucrose as compared to the non-flowering variety Co.442." It is therefore proposed that for the next experiment of this type, it is better to take a flowering variety with low sucrose (like Uba Marot) and a non-flowering variety with high sucrose (like B.3013).

The photoperiodism experiments have again indicated some very interesting results:—(i) The variety Co.285 which flowers early in the season, flowered fairly late when subjected to extra illumination. In the controls Co.285 flowered on 3rd October. With 13 hour day it flowered on 15th October, i.e., 12 days after control. With 14 hour day it flowered on 20th October, i.e., 17 days after the control and with 18 hour day it flowered on 31st October, i.e., 4 weeks after the control; (ii) Another early flowering variety G.1051 when subjected to 13 hour day and 14 hour day treatments also flowered late. It flowered in the control on 13th September whereas with the above treatments of 13 and 14 hour day it flowered on 10th October, i.e., four weeks after the control; (iii) The variety POJ. 2961 when subjected to the treatment of 16 hour day for a period of two months before the usual time of flowering, flowered on 10th October 1947 whereas in the controls it flowered on 30th October 1947. Thus the flowering was hastened by three weeks; (iv) G.1051 (early flowering variety) when subjected to 9 hour day i.e., 15 hours darkness flowered on 31st August 1947 two weeks earlier than the controls.

As regards the effect of irrigation and manures, Poovan, a non-flowering variety showed symptoms of flowering with a lower dose of nitrogen and additional irrigation and G.3011, a non-flowering type of *S. Spontaneum* flowered with 100 lbs. of nitrogen and extra irrigation. In two other varieties which flower usually sparsely, profuse flowering was obtained by treatments involving less manure and increased irrigation.

(e) Pests and Diseases

A Senior Entomological Assistant and a Senior Mycological Assistant are now working at the Station in the Scheme of Additional Staff. Their main work is to watch for pests and diseases and to keep the cane plots free from them. The Assistants have helped in examining the cane material thoroughly before planting.

The incidence of *Argyria* sp., *Diatrea* sp., and *Scirpophaga* sp., as also the attack of *Pyrilla* have been recorded. In the case of *Pyrilla*, the egg parasitisation and stylopisation of nymphs was observed from May onwards. *Sesamia* and *Emmalocera* have been

found only in small numbers and the damage from them was negligible. Both *Aphis sacchari* and *A. maidis* have been observed but the latter in smaller numbers. The plants infested by *A. maidis* showed symptoms of mosaic. Termites have caused some damage to planted setts but more particularly in the Second Ground Nursery. An experiment to study the effect of D.D.T. and Gammexine on controlling the termite attack has been laid out.

In regard to diseases, the plots are free from smut and red-rot except for stray cases in certain seedlings in the Second Ground Nursery where smut was noticed, and in a few clumps of the variety Red Mauritius in which red-rot was noticed. Mosaic was however severe on some 15 varieties. Precautionary measures have been taken. An experiment has been laid out to find the susceptibility to red-rot of 59 Co. canes of Co.213 parentage. The plants will be inoculated by the plug method with a strain of *Colletotricum falcatum*, Went, to be obtained through the courtesy of the Head of the Division of Mycology, Indian Agricultural Research Institute, New Delhi. In addition to 59 Co. canes, 10 varieties of *S. spontaneum* have also been taken up for this experiment.

IV.—SUGARCANE SUB-STATION, KARNAL

There was interruption in the work of the Sub-Station owing to disturbed conditions in East Punjab.

(a) *Live Herbarium*.—The total number of varieties planted for 1947-48 season was 741 consisting of 345 Co. canes, 124 North Indian canes, 90 exotics, 80 wild *Saccharums* and allied genera, 84 other varieties and 18 Coks. Four to eight rows were given to each variety to study the crop for identification work with some precision. This crop was ratooned for 1948-49 season.

(b) *Notes on early growth and vigour of cane varieties*.—The year under report was particularly dry. The total rainfall from the planting of sugarcane to the end of July was only 1.63 inches compared to 11.16 inches during the corresponding period of last year. The maximum temperature during the year has generally been higher than usual. This gave an opportunity to observe the drought resistance of the various sugar cane varieties. Among the Co. canes that are used as parents, Co.221, Co.243, Co.281, Co.335, Co.349, Co.357, Co.359, Co.360, Co.361, Co.363, Co.364, Co.365, Co.402 and Co. 415 and most of the noble types of canes and exotics suffered from drought. But their seedlings raised to the status of Co. canes namely Co.270, Co.285, Co.290, Co.312, Co.313, Co.385, Co.395, Co.408, Co.412, Co. 419, Co.421, Co.426, Co.464, Co.524, Co.527 and Co.545 were found to be resistant to adverse conditions. On the whole the popular Co. canes withstood the summer well. This severe droughty condition affected the cane formation in most of the varieties. Early cane formation was noticed only in Uba Marot, Co.285, Co.312 and eight other Co. canes viz., Co.542, Co.543, Co.549, Co.550, Co.551, Co.552, Co.553 and Co.554 which it is interesting to note are seedlings of S.C.851.

V.—SPONTANEUM EXPEDITION SCHEME

The Assistant Botanist of the Scheme joined during the year and the exploratory work was started in January 1948. Twenty-six types belonging to *S. spontaneum*, four types of *Erianthus arundinaceus*, two of *Sorghum*, two of Bamboo and one of *Arundo Donax* were collected from the South Kanara, Malabar, Coimbatore and Nilgiris districts in South Madras. The collections have been made from saline areas, narrow water channels in plains, moist and dry sandy river beds, dry deciduous and moist ever-green

forest areas and swamps on higher plateaux on the hills. Photographs *in situ* of all the interesting types have been taken to keep a record of the association and habitat of these plants. Among the interesting forms are two types of *S. spontaneum* and one of *Erianthus* which are likely to be resistant to salinity. One of the types of *Spontaneum* collected from the Anamalais at an altitude of 2,000 feet is a very tall form with erect habit.

VI.—RECEIPT AND DESPATCH OF CANES

A. Receipts—

(i) *as canes*—

1. From Dr. C. S. Loh, Director, Sugarcane Research Institute, Taiwan, China
Three forms of *S. spontaneum*—Taiwan 1, 2 and 3.
2. From Dr. E. W. Brandes, Head Pathologist, Bureau of Plant Industry, U.S. Department of Agriculture.
(a) Six types of *S. spontaneum* viz., Aegyptiacum, Pasoeroen, Kloet, Kapandjen, 28 N.G. 292 and Djatirota.
(b) Six varieties viz., *S. robustum* (28 N.G. 219), *S. edule* (28 N.G.—38), C.P. 33-310, C.P. 34-79, C.P. 34-120 and C.P. 36-13, but these were not passed by the Mycologist because of diseased condition.
3. From the Director, Kwangsi Agricultural Experiment Station, Kwangsi, China.
Two indigenous varieties, Loche and Hwaichi Red but these were not passed by the Mycologist because of the diseased condition.
4. From Dr. H. H. Dodds, Director, South African Sugar Experiment Station, Natal.
Eight 'N.Co.' varieties, but these had to be discarded for want of certificate of freedom from Fiji disease.
5. From the Sugarcane Botanist, Jullundur.
Co.L.5 and Co.L.9.
6. From the Assistant Cane Agronomist, Gorakhpur.
Co.370 thin (Mamchua) for identification.
7. From the Assistant Collector of Customs, Bombay.
M.134/32 which had been imported from Mauritius by Messrs. M. L. Dahanukar & Co., Bombay. Did not germinate.
8. From Sugarcane Research Officer, Hebbal, Mysore.
Eight 'I.C.' varieties and 'Mysray 130'.

(ii) *as seeds*—

From Dr. E. W. Brandes, Head Pathologist, Bureau of Plant Industry, U.S. Department of Agriculture.
S. Spontaneum—(1) Amu Darya 59 and (2) Amu Darya 60. Did not germinate.

B. Despatch—

(a) *inland*—

- I. *as canes*.—Ninety seven cane varieties were despatched to 32 places in India.
- II. *as seeds*.—(i) *To Shahjahanpur*.—(1) Co.385 × Co.312, (2) Co.453 × Co.557, (3) Co.464 × Co.313, (4) Co.527 × Co.453, (5) Vellai × P.o.j.2878, (6) Vellai × B.3412, (7) P.o.j.213 × B.3412 and (8) P.o.j.2878 × B.3412.
(ii) *To Jullundur*.—(1) Co.312 × Co.285 and (2) Co.312 × Co.313.

(b) *Foreign*—

- (1) Cuttings of twenty two varieties and seeds of G.1051 G.C. were sent to Dr. E. W. Brandes, Head Pathologist, Bureau of Plant Industry, U.S. Department of Agriculture.
- (2) Seeds of three varieties as also of three grasses (supplied by the Systematic Botanist, Agricultural College and Research Institute, Coimbatore) were sent to Dr. Carl O Grassel, Associate Botanist, Bureau of Plant Industry, U.S. Department of Agriculture.
- (3) Four varieties were supplied to Dr. Felix D. Maramba, Director of Plant Industry, Manilla, Philippines.
- (4) Cuttings of Co.617 and *S. spontaneum* (Coimbatore) were sent to the Director Botanical and Plant Breeding Station, Ministry of Agriculture, Orman, Egypt.
- (5) Three varieties were supplied to Mr. N. R. Purnariksha, Chief of Division Office of the Experiment Station, Department of Agriculture, Bangkok Siam.
- (6) Cuttings of Sarethia, *S. robustum* and three types of *S. Spontaneum* were supplied to Dr. C.S. Loh, Director, Sugarcane Research Institute, Taiwan, China.

VII.—NEW COIMBATORE CANES

For some time now a demand has been insistently made, and rightly, that a greater number of Co. canes be released to the Provinces to give a greater choice for selection of better varieties suitable to the different tracts. The only difficulty in meeting this justified demand has been the limitation of land at the Station. But the demand is so justified that it was felt that without waiting for the proposed expansion of the Station a greater number of Co. canes might be released this year itself. Accordingly thirty new Co. Canes were released to the Provincial Stations during the year. It has to be mentioned, however, that the correct method of releasing more canes would be to select them from a larger population for which extra land is necessary and the expansion of the Station is therefore essential.

The parentages and general characteristics of these canes are given below. In the selection of the canes an attempt has been made to cover a wide range of types.

S. No.	Co. No.	Parentage.		General Characteristics.
1.	Co. 660.	Co. 213 × P.O. J. 2878.	...	Co. 331 type but sparser in flowering. Mid-season (18.65).
2.	Co. 661.	Co. 213 × (Co. 385 × Co. 301)	...	Co. 331 type. Late. (16.01).
3.	Co. 662.	Co. 349 × Co. 301.	...	Co. 419 type but sparser in flowering and not so tall. Mid-season. (17.31).
4.	Co. 663.	-do-	...	Co. 421 type. Sparser in flowering and not top heavy. Easy of trashing. Mid-season (16.43).
5.	Co. 664.	Co. 349 × African Sorghum (A. S. 4601).	...	P. O. J. 2878 type but with harder rind. Mid-season (19.33).
6.	Co. 665.	Co. 349 × African Sorghum (A. S. 4653).	...	Co. 349 type. Moderate in height and not likely to lodge. Early (18. 64).

S.		Parentage.		General Characteristics.	
No.	Co. No.				
7.	Co. 666.	Co. 351 × Co. 545.		...	Sorghum is one of its grand parents. Early (19.31).
8.	Co. 667.	-do-		...	Same parentage as above but only a mid-season cane. (17.93).
9.	Co. 668.	Co. 357 × Co. 545.		...	Sorghum is one of its grand parents. An early cane with good purity and fair yield (17.58).
10.	Co. 669.	Co. 443 × Purple Mauritius.		...	A thickish cane of medium height. Mid-season (17.81).
11.	Co. 670.	Co. 508 × Co. 301.		...	Co. 508 type. Early. (18.88).
12.	Co. 671.	Co. 508 × Co. 395.		...	Co. 395 type. Borer attack very moderate. Mid-season (17.19).
13.	Co. 672.	Co. 508 × Co. 453.		...	Co. 453 type. Heavy yielder. Late. (16.91).
14.	Co. 673.	Co. 508 × Co. 545.		...	Co. 421 type but slightly thinner. Vigorous in growth Mid-season. (17.36).
15.	Co. 674.	Co. 508 × (Co. 349 × Uba Marot).		...	Co. 213 type but with better sugar. Uba Marot is one of its grand parents. Mid-season (18.65).
16.	Co. 675.	Co. 524 × Co. 301.		...	Co. 419 type, Late. (17.30).
17.	Co. 676.	Co. 527 × Co. 508.		...	A mid-season cane of good habit (16.70).
18.	Co. 677.	Co. 603 × Co. 301.		...	Co. 603 type but heavier yielder. Of likely use as a chewing cane. Early. (19.63).
19.	Co. 678.	-do-		...	Co. 603 type. Heavier yielder. Late. (16.39).
20.	Co. 679.	C. 616 × (Co. 285 × Co. 440).		...	Co. 419 type. A mid-season cane of fair sucrose. (19.73).
21.	Co. 680.	Co. 625 × Co. 605		...	Co. 421 type. Late (15.42).
22.	Co. 681.	P. O. J. 2878 × Co. 301.		...	A mid-season cane approaching Co. 421 type (16.13).
23.	Co. 682.	P. O. J. 2878 × Co. 453.		...	Co. 421 type. Early ripener of good yield. (21.04).
24.	Co. 683.	P. O. J. 2878 × B. 3412.		...	Co. 421 type but heavy yielder. Same parentage as Co. 421. Tall growing but not likely to snap. Mid-season. (18.08).
25.	Co. 684.	P. O. J. 2878 × (Fiji B., G. C.)		...	Co. 419 type, Late. (15.63).
26.	Co. 685.	(Co. 331 × S. W. III) × (Co. 285 × Co. 440).		...	Co. 421 type. A heavy yielding late cane. (13.06).
27.	Co. 686.	(Co. 421 × Co. 440) × Co. 281.		...	Co. 313 type. Early ripener of good yield. (19.58).
28.	Co. 687.	(Co. 421 × Co. 440) × Co. 419.		...	Co. 419 type. Heavy yielding late cane (13.24).
29.	Co. 688.	(Fiji B., G. C) × Co. 475.		...	Co. 419 type. Early cane of good sugar. (21.04).
30.	Co. 689.	(Fiji B., G. C) × (Co. 419 × B. 3412)		...	Co. 419 type. Tall growing but not likely to snap. Mid-season (18.05).

Note.—Figures in brackets refer to sucrose percent in juice of the best analysis during the year. As regards the parentages of Co. 664 and Co. 665, it has to be mentioned that, since parthenogenetic seed formation is common in intergeneric crosses the parentage of these two seedling varieties should be regarded as tentative.

VIII.—MISCELLANEOUS

(a) *Bulletin on Co. canes.*—Morphological descriptions of Co. Canes are published by the Coimbatore Station from time to time. Descriptions of certain of the recent canes are overdue and the Indian Central Sugarcane Committee has desired that a bulletin be prepared describing the Co. canes that are being grown in different parts of India. Descriptions have accordingly been recorded along with paintings and line drawings of twenty-one varieties. In connection with these descriptions, a visit to the Provincial Stations has been made to record variations in characters that sometimes occur from place to place. Certain of these Stations could not be visited during the period and a visit will be made to them shortly to complete the descriptions. The varieties that are being described are (1) Co.244, (2) Co.301, (3) Co.312, (4) Co.313, (5) Co.331, (6) Co.349, (7) Co.356, (8) Co.370, (9) Co.385, (10) Co.393, (11) Co.395, (12) Co.419, (13) Co.421, (14) Co.449, (15) Co.453, (16) Co.467, (17) Co.475, (18) Co.508, (19) Co.513, (20) Co.527, and (21) Cok.32.

(b) "*Deterioration*" of Co.419.—In 1946, the Officer-in-charge of the Agricultural Research Station, Padegaon, Bombay Province, sent a quantity of setts of Co.419 for growing and trial at Coimbatore to ascertain whether there has been any deterioration in the variety, as it had been reported to give lower yields in several places in the Province. The required quantity of this variety from Coimbatore material was also sent for growing at Padegaon in order to compare its growth with the local material of Co.419.

The material obtained in 1946 from Padegaon was multiplied and planted in 1947 in a preliminary varietal trial against pure and healthy material maintained at Coimbatore. Owing to limitation of land the usual plot size of $1/40$ of an acre could not be given to each plot. However, two rows were devoted to each plot and they were arranged in the AB, BA pattern and replicated 4 times. The experiment was conducted both in the wetland and in the garden land. The data have been analysed by using Student's Method of paired values and the critical difference D was calculated by using the 5% value of t. From the data which are given below it will be seen that the differences between the two materials in regard to (1) the weight of canes per row, (2) brix, (3) sucrose and (4) Purity were not statistically significant.

TABLE II.

Characteristics	Garden land.				Wet land.			
	Control. Co. 419.	Padegaon. Co. 419.	Differ- ence.	Critical difference (5%)	Control Co. 419.	Pade- gaon. Co. 419.	Differ- ence.	Critical difference (5%)
1. Weight of canes per row. Lbs. ...	262	246	16	86.82	127	162	35	36.71
2. Brix. % ...	16.69	17.72	1.03	3.382	18.52	21.31	2.79	4.861
3. Sucrose % ...	14.28	15.35	1.07	3.044	15.15	17.63	2.48	3.500
4. Purity % ...	85.4	86.40	1.00	2.625	81.80	82.70	0.90	2.964

The above result is quite what might have been expected, because strictly speaking, deterioration cannot be expected in sugarcane varieties as the multiplication is by vegetative means and thus there is no change in the genetical make-up. References to the so called deterioration of sugarcane varieties in cultivation are received from cane growers also and in view of the importance of this experiment it is proposed next year to lay out the experiment with the proper plot size, viz., $1/40$ of an acre. The cane growers can, however be assured straight away that there is no deterioration as such in sugarcane, unless a mutation occurs changing the genetic composition, and all that is necessary for them is to see that their crop is free from pests and diseases and is planted in a soil whose fertility is maintained by suitable manuring.

The question of replacing a variety by another superior one stands on a different footing altogether. Superior varieties by breeding are becoming available rapidly and may replace the extant varieties because of their superior intrinsic worth and not because the extant varieties have deteriorated.

IX.—PROGRAMME OF WORK (1948-49)

Breeding with particular emphasis on specialised characters as "early" and "late" maturity, disease and pest resistance, non-pithy character of the stem and chewing quality. Attention will also be paid to evolving fodder canes.

Cyto-genetical studies with a view to investigating the mode of inheritance of characters in *Saccharum* and allied genera.

Physiological studies on the chemical composition of flowering and non-flowering cane varieties and the initiation of reproductive phase in non-flowering canes by photo-period treatments and chemicals.

The relationship of anatomical and other characters to disease, drought and frost resistance and their inheritance in cane hybrids.

Determination of albuminoids, colloids, etc., in the seedling canes before they are released from Coimbatore and a study of the manufacturing qualities of the Co. canes.

The exploration and collection of wild forms of *Saccharum* and allied genera.

Report of the Head of the Division of Soil Science and Agricultural Chemistry

I.—RESEARCH AND INVESTIGATIONS

(i) Agricultural Chemistry

Experiments to obtain confirmatory data regarding the beneficial after effects of phosphate manuring of berseem are being continued. The new set of experiments laid down in series I and II in rabi 1946-47 are designed to study the effect of fertilizing berseem with P, K, NP, NPK and F.Y.M. in berseem-guar—wheat and berseem-fallow-wheat rotations respectively. The study is purely agronomical and is being conducted by the Agronomy Division.

Phosphate manuring of berseem (series III):—In this series a combined chemical and agronomical investigation is planned to study to what level berseem treated with phosphate fertilizers and followed by guar for three years builds up soil fertility as judged by their residual effect on subsequent yields of wheat and maize.

The experiment was started in rabi 1946-47. Manurial treatments applied for acre in the berseem crop were as follows :—

Nil	...	...	A. No manure
50P	...	...	B. Super phosphate at 50 lbs. P_2O_5
100P	...	...	C. „ „ 100 lbs. „
50P + 80 K	...	...	D. „ „ 50 „ + K_2SO_4 at 80 lbs. K_2O
100P + 80 K	...	...	E. „ „ 100 „ + „

The treatments were randomized in 6 blocks.

The yield data reported last year indicated that increased yields may be obtained by the application of phosphate to the berseem crop although the differences were statistically not significant. There was little difference in yields between the application of 50 and 100 lbs. P_2O_5 , as also the uptake of P_2O_5 under these doses. Addition of potassic fertilizer with super phosphate lowered crop yield as well as uptake of P_2O_5 and CaO by the plants.

The area was cropped with guar in kharif 1947 and berseem again in rabi 1947-48. The guar crop failed due to water-logged conditions which developed in the major portion of the area. The yield data was entirely vitiated and could not be interpreted statistically. Samples of the guar crop under the different treatments were analysed for N, P_2O_5 and CaO.

The average percentage composition of these is given below along with the yield figures.

Treatment			Yield Lbs. per acre.	N%	P ₂ O ₅ %	CaO%
A.	...	...	3770	3.55	0.50	3.99
B.	...	...	2340	3.22	0.50	3.81
C.	...	...	3145	2.98	0.49	3.69
D.	...	...	2825	3.24	0.53	3.85
E.	...	...	2480	3.11	0.51	3.91

The mineral constituents in the crop under the different treatments do not show any marked difference. The uptake of minerals might also have been affected by water logging of part of the area. No conclusions can be drawn from this year's data.

The berseem crop taken on this area in Rabi 1947-48 appeared normal and 4 cuttings of the crop were taken till the end of March.

Composite samples of each cutting are being analysed for N, P₂O₅ and CaO and results will be reported next year.

To study the effect of heavy doses of complete fertilizers (N, P. and K.) without legumes in building up soil fertility and maintaining crop yields of wheat and maize (Series IV).

The experiment was started in Rabi 1946-47 with a wheat crop which received the following manurial treatments per acre.

Nil ... A—No manure.

60N + 100P + 80K .. B—Am₂SO₄ @ 60 lbs. N + Super @ 100 lbs. P₂O₅ + K₂SO₄ @ 80 lbs. K₂O.

60N + 100P + 80K .. C—F.Y.M. @ 60 lbs. N + Super and K₂SO₄ as in B making allowance for P₂O₅ and K₂O in F.Y.M.

60N + 100P + 80K .. D—Castor cake @ 60 lbs. N + Super and K₂SO₄ as in B making allowance for P₂O₅ and K₂O in castor cake.

The treatments were randomized in 6 blocks.

Yields of wheat obtained were statistically not significant. Composite samples of grain and straw were analysed separately for N, P₂O₅ and CaO. The uptake of these minerals and the yield figures are given below.

Yield of wheat and recovery of certain minerals in the crop 1946-47.

Treatment	Yield per acre					Differences over control		
	Grain lbs.	Straw lbs.	N lbs.	P ₂ O ₅ lbs.	CaO lbs.	N lbs.	P ₂ O ₅ lbs.	CaO lbs.
A. (Control) ...	1563	4187	57.98	19.30	25.42	...	...	...
B. ...	1649	4785	60.54	18.92	24.62	2.56	-0.38	-0.79
C. ...	1761	4983	62.01	22.35	30.34	4.03	3.05	4.92
D. ...	1575	4695	64.52	18.02	25.05	6.54	-1.28	-0.23

The area was cropped with maize in kharif 1947. Yield of grain obtained under the different treatments were statistically not significant. Composite samples of grain, cobs and straw were analysed separately for N, P₂O₅ and CaO. The uptake of these constituents along with the yield figures are given below :—

Yield of maize and recovery of fertilizer constituents in the crop 1947.

Treatment	Yield per acre					Difference over control			
	Grain lbs.	Cobs lbs.	Straw lbs.	N lbs.	P ₂ O ₅ lbs.	CaO lbs.	lbs. N	P ₂ O ₅ lbs.	CaO lbs
A. (Control)	1548	333	7463	60.12	18.52	70.89	...	...	...
B.	1696	381	8550	87.39	29.32	81.36	27.27	10.80	10.47
C.	1505	318	6641	68.35	24.79	59.14	8.23	6.27	-11.75
D.	1802	368	8181	78.24	32.20	73.91	18.12	13.68	3.04

This completes one cycle of the wheat-maize rotation in this series. The total uptake of the mineral constituents in both the crops and the percentage recoveries of the added manures are summarized below. The figures are calculated on the basis of the percentage composition and yield of the crop computed per acre. The individual plot yields showed wide variations under the same treatment due to which the experiment was statistically not significant. This is being further looked into. The data presented here may be regarded as purely indicative.

Total recoveries of mineral constituents in wheat and maize.

Treatment	Difference over control			Percentage recovery of added manures				
	N	P ₂ O ₅	CaO	N	P ₂ O ₅	CaO	N	P ₂ O ₅
A. (Control) ...	118.10	37.82	96.34	...	...	...	...	...
B. ...	147.93	48.24	105.99	29.83	10.24	9.68	49.7	10.42
C. ...	130.36	47.14	89.48	12.26	9.32	-6.83	20.4	9.32
D. ...	142.76	50.22	99.56	24.66	12.40	3.25	41.1	12.40

The amounts of the added fertilizer constituents removed by the wheat crop above were small but the succeeding kharif crop of maize showed better utilization of the fertilizers applied. The combined uptake by wheat and maize given in the table above indicates that nitrogen was most efficiently utilized from sulphate of ammonia with a recovery of 49.7% of its nitrogen by the two crops. Castor cake yielded 41.1% of its nitrogen while F.Y.M. was the least efficient giving a recovery of 20.4% of its nitrogen. With regard to P₂O₅ recoveries, castor cake-superphosphate application shows slight superiority over sulphate of ammonia-superphosphate combination. With F.Y.M. the recovery of P₂O₅ was again the lowest. These observations indicate that the availability of the nutritional minerals in F.Y.M. is comparatively low.

SERIES V.—*The effect of introducing a legume like peas in rotation with wheat and maize as under the above experiment.*

Manurial treatments and the layout of the experiment were the same as in series IV. The rotation of crops in this series however, includes a crop of peas to be taken after maize. The cropping programme to be followed is as under:

			Rabi	Kharif			
1st year	...	...	Wheat	Maize	...	...	...
2nd "	...	...	Peas	"	...	...	...
3rd "	...	...	Wheat	"	...	...	...
4th "	...	...	Peas	"	...	...	...

The area was manured as in series IV and a wheat crop was taken in rabi 1946-47. Yields of wheat were statistically not significant. The crop was analysed for N, P₂O₅ and CaO. The total uptake of these constituents is given below along with the yields of grain and straw.

Yields of wheat and recovery of certain mineral constituents in crop 1946-47.

Treatment	Yield lbs. per acre		N lbs.	P ₂ O ₅ lbs.	CaO lbs.	Difference over control		
	grain	straw				N	P ₂ O ₅	CaO
A. (Control) ...	1745	4286	62.45	18.12	15.44	...	...	...
B. ...	1447	4743	66.52	17.43	17.26	4.07	-0.69	1.82
C. ...	1742	4887	69.28	17.74	18.72	6.83	-0.38	3.28
D. ...	1502	4345	63.87	18.28	17.16	1.42	0.16	1.72

No marked differences in the uptake of these mineral constituents is observed as a result of the fertilizer treatments applied.

The area was cropped with maize kharif 1947 and the different parts of the crop were analysed for N, P_2O_5 and CaO as in series IV. The calculated recoveries of these minerals and yield figures are tabulated below :—

Yields of maize and recovery of certain mineral constituents in the crop 1947.

Treatment	Yield per acre			N lbs.	P_2O_5 lbs.	CaO lbs.	Diff. over control		
	Grain lbs.	Cobs lbs.	Straw lbs.				N lbs.	P_2O_5 lbs.	CaO lbs.
A. (Control)	1381	298	7058	60.17	16.32	56.44	...	...	...
B. ...	978	271	5907	50.36	18.32	38.11	-9.81	2.00	-18.33
C. ...	1061	268	6561	56.29	27.00	64.64	-3.88	10.68	8.2
D. ...	1201	253	5868	56.65	20.63	48.98	-3.52	4.31	-7.46

Yields of maize were statistically not significant.

The average yields of wheat as well as maize grain obtained in this area were highest under no manure treatment and bear no comparison with the order of yields obtained in series IV which was identically treated and cropped. Individual plot yields showed wide variations under the same treatments. The uptake of minerals computed on the basis of the yield data gave negative values. The experiment was vitiated due to soil heterogeneity and no conclusions can be drawn.

(ii) Soil Chemistry

In the area of about 12 acres under the manurial experiments, 13 profiles were morphologically examined in 1946. The results of this examination was reported in the last year (1946-47). Out of these 13 profiles 6 profiles were selected and 22 soil samples were analysed in the laboratory. The results of the profile examination and analyses has been dealt separately under Soil Survey Section, but a brief mention of some important properties is made here. The texture of the surface layer of about 0-12" is sandy loam as the clay content is between 12 and 22% which goes on slightly decreasing with the depth. The percentage sand is between 55 and 83%. The pH is mildly alkaline as it is between 7.5 and 8.4. The total soluble salt is between 0.04 and 0.07% and is not dangerous for the growth of plant.

Similarly samples 0-9" from individual plots of the same area were collected to ascertain the nutrient status—of these plots before the experiments (explained under Agricultural Chemistry section) were started. These samples were then made into composite sample for each block. Within each block a sample of no manure was analysed separately while all the rest of the samples from different plots to be treated with manures were made into one composite sample. The results of analyses are given below, under each series.

Series III.—To study to what level berseem treated with phosphatic fertilizers and followed by guar for three years builds up soil fertility as judged by their residual effect on subsequent yields of wheat and maize.

The variation within a block and between the blocks in the content of N, P and K both in HCl soluble and citric acid soluble is practically insignificant. However, the soils show fairly high content of N which is of the order of 0.05 to 0.06%. Although total HCl soluble P_2O_5 does not seem to be very high yet 25% of it is in the available form content of CaO is quite adequate.

After the first year of manuring with phosphatic fertilizer and cropping of berseem soil from the individual plots was analysed to find any changes due to the cropping of berseem with the phosphatic manure has taken place, the results of analyses are given below :—

Nutrient status of soils after phosphatic application to berseem crop (Average of 6 replicates for each treatment).

	A	B	C	D	E
Treatment.	No manure.	Super @ 50 lbs. P_2O_5 .	Super @ 100 lbs. P_2O_5 .	Super + K_2SO_4 50 lbs. + 80 lbs. K_2O .	Super + K_2SO_4 100 + 80 lbs. K_2O .
Moisture.	2.43	2.44	2.23	2.34	2.50
N.	0.06	0.06	0.06	0.06	0.06
HCl soluble P_2O_5	0.12	0.12	0.09	0.09	0.09
„ „ K_2O .	0.75	0.88	0.75	0.59	0.63
„ „ CaO.	0.57	0.68	0.58	0.61	0.62
1% citric acid available P_2O_5 .	0.03	0.03	0.02	0.02	0.02
1% citric acid available K_2O .	0.02	0.03	0.02	0.01	0.01

The analyses of soils do not indicate any residual effect of phosphatic application with 50 lbs. or 100 lbs. P_2O_5 to the berseem crop. This being the first year of application, the effect is not very marked. The increase in the yield of berseem has also been reported (1947-48) to be very little. Similarly the removal of P_2O_5 by the crop over that of added was only about 7% in the case of super alone and about 4 to 6% in the mixture of super+potash. Such minor differences are not shown by these soils.

Series IV.—To study the effect of heavy doses of complete fertilizers (N, P and K) without legumes in building up soil fertility and maintaining crop yields of wheat and maize for comparison with series I, II and III the analyses of soil before the manurial experiment was laid showed the following results.

*Nutrient Status of Samples from no Manure Plot and of the Composite Samples
Obtained from Series IV.*

Determinations.	BLOCK 1. No Compo- manure. site.	BLOCK 2. No Compo- manure. site.	BLOCK 3. No Compo- manure. site.	BLOCK 4. No Compo- manure. site.	BLOCK 5. No Compo- manure. site.	BLOCK 6. No Compo- manure. site.	
Moisture ...	1.96	1.95	1.71	2.32	2.39	2.35	2.40
Nitrogen ...	0.07	0.06	0.07	0.08	0.07	0.05	0.09
HCl soluble P ₂ O ₅ ...	0.09	0.05	0.08	0.08	0.10	0.10	0.08
HCl soluble K ₂ O ...	0.50	0.46	0.54	0.49	1.58	1.15	1.61
HCl soluble CaO ...	0.63	0.66	0.61	0.64	0.88	0.60	1.01
Citric acid soluble P ₂ O ₅ ...	0.02	0.02	0.02	0.02	0.03	0.02	0.02
Citric acid soluble K ₂ O ...	0.01	0.02	0.02	0.04	0.02	0.04	0.01

The variations within a block and between the blocks in the content of N, P and K are not much to reflect upon the growth of plant.

Series V.—To compare the effect of introducing a legume like peas in rotation with wheat and maize with the results obtained in Series IV.

The nutrient status of these soils as studied before the manurial experiment was conducted, showed the following results :—

SERIES V.—*Nutrient Status of Samples from no Manure and of the Composite Samples Obtained from Series IV.*

Determinations.	BLOCK 1. No Compo- manure. site.	BLOCK 2. No Compo- manure. site.	BLOCK 3. No Compo- manure. site.	BLOCK 4. No Compo- manure. site.	BLOCK 5. No Compo- manure. site.	BLOCK 6. No Compo- manure. site.
Moisture (air-dry) ...	2.74	2.00	2.09	2.29	2.77	3.22
Nitrogen ...	0.09	0.08	0.08	0.07	0.08	0.07
HCl soluble P_2O_5 ...	0.11	0.12	0.09	0.08	0.09	0.10
HCl soluble K_2O ...	0.58	0.88	0.88	0.75	1.09	1.21
HCl soluble CaO ...	0.49	0.60	0.63	0.55	0.56	0.69
Citric acid soluble P_2O_5 ...	0.02	0.02	0.03	0.02	0.02	0.02
Citric acid soluble K_2O ...	0.01	0.01	0.01	0.04	0.02	0.01

The variation within the block and in between the block does not appear to be much but the content of N and P (total) is rather high.

Series VI.—Fertility building experiment with organic manures in combination with fertilizers.

Nutrient Status of Samples from no Manure and of the Composite Samples Obtained from the set of Green Manuring and Organic Manuring Plots (before the experiment was laid).

Determinations.	BLOCK 1.			BLOCK 2.			BLOCK 3.			BLOCK 4.		
	No manure.	Compo-site from cake plots.	Compo-site from G.M. plots.	No manure.	Compo-site from cake plots.	Compo-site from G.M. plots.	No manure.	Compo-site from cake plots.	Compo-site from G.M. plots.	No manure.	Compo-site from cake plots.	Compo-site from G.M. plots.
Moisture (air-dry).	1.37	1.37	1.37	1.49	1.33	1.33	1.92	1.69	1.90	1.45	1.61	1.65
Nitrogen	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.06	0.07	0.09	0.07
Humus	1.65	1.65	1.25	1.35	1.25	1.30	1.50	1.50	1.30	1.35	1.20	1.65
HCl soluble P_2O_5	0.09	0.09	0.10	0.09	0.09	0.09	0.10	0.10	0.07	0.09	0.09	0.10
HCl soluble K_2O	0.68	0.62	0.69	0.67	0.65	0.67	0.82	0.63	0.77	0.85	0.83	0.75
HCl soluble CaO	0.63	0.65	0.60	0.61	0.51	0.56	0.62	0.67	0.70	0.58	0.56	0.59
Citric acid soluble P_2O_5	0.03	0.04	0.04	0.04	0.04	0.03	0.02	0.02	0.03	0.04	0.04	0.03
Citric acid soluble K_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

The variation in the content of N, P and K within a block and also between a block is very little.

All these series experiments are laid on a fairly homogenous area; the fluctuation in the contents of N, P and K are very insignificant. The general status of nutrient is also fairly high.

The analysis of Andaman soils is in progress.

(iii) Soil Fertility

Study of the mineral deficiency (major elements) using indicator plants and comparison with other methods.—In the previous year it appeared that berseem could possibly be used as an indicator plant for denoting P deficiency of soil. Experiments were planned to study the soil deficiencies by growing suitable plants in pots and plots. The plot experiments were laid out following the Wallace technique. In pot experiments N was supplied as ammonium nitrate, phosphate as superphosphate and potash as sulphate of potash.

Kharif 1947.—With Delhi soil low in available P_2O_5 .—Crop grown was maize. The treatments were O, N_{200} , K_{100} , $P_{29.5}$ and combinations NP; PK; NK; NPK; NPK + Mg; NPK + Zn; NPK + Mg + Zn at N_{200} , P_{200} , K_{200} ; K_{100} level and N_{100} , N_{100} , P_{200} , K_{100} and combinations NPK + Zn, NPK + Mg, NPK + Mg + Zn. Mg was supplied as $MgSO_4$ at 25 lbs. MgO , and Zn was supplied as $ZnSO_4$ at 5 lbs. visible symptoms of P deficiency were noticed when P was omitted. The symptoms were violet strips on the leaves, colouration started from the base of the leaf extending along the main lines and spreading sideways. The P deficiency was markedly clear in NK treatment and N deficiency symptoms of yellowing of leaves and reduced leaf size are pronounced in PK combination. N addition has increased the height and girth of plants P was next to N and K has no effect. Maximum yield was obtained in NP treatment. Individually Mg or Zinc had no effect when added with NPK but Mg + Zn + NPK was better than NPK only at N_{200} level.

With Pusa Soil Low in Available P_2O_5 .—Maize was grown with the treatments as above. Similar deficiency symptoms due to N and P were observed and the intensity of P deficiency was high. Response to P was markedly seen in height and girth and next in effect was that due to N. Good response in yield was obtained in NP treatment. K either alone or in combination with NP depressed the yield. When the N level was raised to 200 this adverse effect K was not noticed. Mg and Zn exerted beneficial effects.

Rabi 1947-48.—Berseem and lucerne were grown in two Delhi soils, Soil I containing low amount of available P_2O_5 and Soil II containing high amount of available P_2O_5 .

Berseem.—With Soil I the treatments* were O, P_{50} , P_{100} , P_{150} , P_{200} , P_{250} with and without the basal dressing of N_{20} , K_{50} and N_{50} , K_{150} and N_{20} , K_{50} , N_{20} , P_{150} , P_{150} , K_{150} . With Soil II the treatments were 0, 100, 150 and 200 lbs. P_2O_5 per acre with and without basal dressing N_{60} K_{150} .

Reddening symptoms in berseem were prominent in plants in soil I receiving no P_2O_5 and doses of P_2O_5 less than 150 lbs. per acre. In the unmanured soil II the number of plants showing reddening symptoms were $\frac{1}{3}$ to $\frac{1}{2}$ of those observed in the unmanured soil containing low available P_2O_5 . After the first cutting reddening symptoms practically disappeared. The yield data of all the cuttings of berseem were statistically examined. The following are the conclusions drawn.

* P_{50} and P_{250} = Super at 50 lbs. P_{25} and 250 lbs. P_2O_5 per acre. N_{20} , N_{60} = ammonium nitrate at 20 lbs. and 60 lbs. N_{50} , K_{150} = sulphate of potash at 50 lbs. K_2O and 160 lbs. K_2O respectively.

In soil containing low available P_2O_5 , significant increased yields were obtained (90% over no manure) with 100 lbs. P_2O_5 per acre among the doses tried. The basal dressing of $N_{50}K_{150}$ was superior to the treatment $N_{20}K_{50}$ and to the control. $N_{20}K_{50}$ was not better than control. Among the individual elements added P_2O_5 gave better yield than N and K. NPK and NP were better than P alone. Between P and KP, the difference was not significant. There was no significant difference between NP and NPK. In general the main effect due to P was most significant and next was that due to N. The remaining main effects and interactions were not significant.

With soil high in available P_2O_5 (0.023%), treatments at 150 lbs. and 200 lbs. P_2O_5 gave 26% and 33% increase in yield. The control in the series in soil containing high P_2O_5 gave more yield than an application of 250 lbs. P_2O_5 in soil with low available P_2O_5 content.

Lucerne.—With soils I and II the treatments were (1) no manure; (2) $N_{60}K_{150}$; (3) $N_{60}K_{150}P_{100}$; (4) $N_{60}K_{150}P_{150}$, $N_{60}K_{150}P_{100}$ treatments were superior to $N_{60}K_{150}P_0$ and untreated soil emphasizing the need for P_2O_5 . $N_{60}K_{150}$ did not increase the yield over no manure.

Field experiments (kharif 1947).—The experiments were laid out in middle block 9D. The plants grown were sunflower, maize, soyabean and Sudan grass. The treatments were (1) unmanured, (2) F.Y.M. at 80 lbs. N per acre; (3) Sulphate of ammonia at 80 lbs. N per acre; (4) NPK (Sulphate of ammonia at 80 lbs. N + Super at 100 lbs. P_2O_5 + Sulphate of potash at 50 lbs. K_2O), (5) NP; (6) NK; (7) PK; (8) NPK + Mg at 25 lbs. MgO per acre; (9) NPK + $MnSO_4$ at 20 lbs. per acre; (10) NPK + $ZnSO_4$ at 5 lbs. per acre; (11) NPK + B as Boric acid at 8 lbs. per acre and (12) NPK + Mg + B + Zn + Mn.

From the chemical analysis data it was observed that the soil was well supplied with the nutrients N, P and K and the soil was at a high level of fertility. No deficiency symptoms were observed. The yields of the crops were high. Response to N was indicated.

Rabi (1947-48).—In this season experiments were conducted in Middle Block C₂ where the soil is at a low level of fertility and in Main Block 9D where the fertility is at a high level. The soil profiles were studied and the surface soil samples were chemically analysed.

Treatments. For plot 9 D.	For Middle Block C ₂ .
NPK	NPK
NP	NP
NK	NK
NPK + B	NPK + Mg
NPK + Mn.	NPK + B
NPK + B + Mn.	NPK + Mn.
	NPK + Mn + B + Mg.
	PK
	No manure.

Each set has one limed and another unlimed series. Sulphate of ammonia was applied at 400 lbs. N per acre, superphosphate at 448 lbs. per acre, Boric acid at 7 lbs., $MnSO_4$ at 100 lbs., $MgSO_4$ at 140 lbs. and lime 4 cwt.

The crops grown in 9D were potatoes, oats, rape, sunflower and lettuce. The crops grown in Middle block C₂ were potatoes, oats, rape, gram and lettuce.

Periodic growth observations were taken in both the plots. In 9 D the crop growth was good and no visible deficiency symptoms were seen.

In middle block C₂ the crops showed N and P₂O₅ deficiency symptoms where the treatments did not include these constituents.

Potatoes.—The plants in control and PK treatments were stunted with little branching. The leaves were pale green and small in size showing N deficiency. Plants receiving NK treatment had thick green leaves but the stature was short and stems were erect and stiff. The leaflets were showing upright growth and forward rolling of leaves was observed. Among minor elements Mn had some beneficial effect.

Oats.—N and P₂O₅ deficiency symptoms were noticed. N deficiency was shown by stunted growth, thin roots and small leaves with pale green colour and meagre tillering. P deficiency was shown by the dark green colour of the leaves. The plants in NK treated plot showing this deficiency were thin, stiff and erect and general growth was much less profuse than of plants in NPK treated plot.

Rape.—N and P deficiency symptoms were similar to those in potato except the forward rolling of leaves.

Gram.—Yellowing and bronzing was seen in most of the plants in plots where either N or P or both were not added. Mn singly or combined with Mg+B appeared to have some beneficial effect when added along with N+P+K treatment. Mg indicated some depressing effect.

Lettuce.—The plants showed N and P deficiency symptoms. Liming had no effect.

Rapid tissue tests confirmed the N and P deficiency symptoms.

NP treatment gave the best yield.

Lysimeter studies.—The effect of phosphatic fertilisers on soil fertility, crop composition and yields :—

The following table shows the different treatments and crops in the legume rotation and in purely cereal rotation :—

Lysimeter No.			1	2	3	4	5	6	7	8
Season										
1945-46 Rabi	...	...	B	P.B	O.W	N.W	P.W	NP.W	...	...
1946 Kharif	...	...	C	C	M	M	M	M	...	...
1946-47 Rabi	...	...	W	W	W	W	W	W	O.B.	P.B.
1947 Kharif	...	...	C	C	M	M	M	M	C	C
1947-48 Rabi	...	...	O.B.	P ₁ B	O.W	N.W	P ₁ W	NP ₁ W	W	W

(O=Untreated; N=Sulphate of ammonia at 80 lbs. N per acre; P=Super at 100 lbs. P_2O_5 per acre; P_1 =Super at 200 lbs. P_2O_5 per acre; B=Berseem; C=Cowpea; W=Wheat; M=Maruva). In 1945-46 in lysimeter 1 and 9 berseem seed rate was 30 lbs. per acre. This rate was increased to 60 lbs. in lysimeters 7 and 9, in 1946-47, and in lysimeter 1 and 2 in 1947-48, as it was felt that the low yield of wheat in lysimeter 2 in 1946-47 rabi as compared to that in lysimeter 1 might be due to less pronounced effects of P treatment to berseem due to low seed rate.

Khariif 1947 Cowpea and Maruva crops.—Yield of cowpea crop was practically the same in lysimeters 1 and 2 indicating that there was no residual effect of the preceding fertilisers. Crop analysis showed that cowpea in lysimeter 2 had more N, ash, and CaO content than that from lysimeter 1. The amounts of mineral nutrients removed by crop in lysimeter 2 was more than those removed by crop in lysimeter 1.

In lysimeters 7 and 9 where the previous berseem crop was sown at double the seed rate than in lysimeter 1 and 2, cowpea crop yields differed widely. The crop following unmanured berseem gave 64% more yield than that following P treated berseem. However the per cent composition of cowpea in lysimeter 9 with respect to N, ash and CaO was more than that in the crop in lysimeter 7. P_2O_5 and K_2O contents were almost the same. Cowpea crop in lysimeter 7 following unmanured berseem recovered more nutrients N, ash, P_2O_5 , K_2O and CaO than those removed by cowpea following P treated berseem.

In the cereal rotation the maruva crop yields were practically the same in all the lysimeters. Thus there appears to be no residual effect of fertilisers in this season. The amounts of P_2O_5 , K_2O and CaO removed were more or less the same in all the lysimeters in the case of maruva.

Rabi 1947-48 (Wheat and Berseem crops).—Wheat was the crop sown in legume rotation as the third crop (Berseem-cowpea-wheat-Cowpea) in lysimeters 7 and 9 and as first crop in the second series of rotation (wheat-Maruva-wheat-Maruva) in lysimeters 3, 4, 5 and 6. Berseem was sown in lysimeters 1 and 2 as the first crop in the second series of rotation. Superphosphate was applied to berseem at 200 lbs. P_2O_5 per acre as it was felt that this dose would meet its requirements and of the following cowpea and wheat crops. To facilitate the comparison of legume rotation with cereal rotation in lysimeters 5 and 6 the dose of superphosphate was maintained at 200 lbs. P_2O_5 per acre.

In the wheat crop agronomic observations such as height, number of tillers and 1,000 grain weight were noted. The yields were recorded grain and straw were analysed for N, P_2O_5 , K_2O and CaO and recoveries of mineral nutrients by crop were evaluated. In berseem crop dry weight, N, P_2O_5 , K_2O and CaO were determined and removal of nutrients by the crop were evaluated. The following are the general conclusions drawn.

(1) Untreated wheat crop in lysimeter 3 and P treated wheat crop in lysimeter 5 in the cereal rotation showed definite nitrogen deficiency symptoms. The plants were dwarfed and have very few tillers. The foliage was pale yellow and the older leaves were drying and dying out. Nitrogen starvation symptoms were more pronounced in P treated wheat than in untreated wheat. Untreated wheat and N treated wheat showed P deficiency symptoms. In NP treatment no deficiency symptoms were noticed.

No deficiency symptoms were observed either in the wheat crop in the untreated or P treated (berseem-cowpea-*Wheat*-cowpea) legume rotation.

(2) With respect to agronomic characters (height, number of tillers, number of earheads and 1,000 grain weight) NP treated wheat was better than any other treatment in the cereal rotation. Wheat following cowpea after P treated berseem was superior to wheat following cowpea after untreated berseem which was equal to NP treated wheat with respect to these characteristics.

(3) In yields (table) NP treated wheat gave 134% more yield than no manure while N treatment gave 55% more and P treatment 6% less than no manure. In legume rotation the yield of wheat following cowpea after P treated wheat was better than that of wheat following cowpea after untreated berseem. The former gave 280% more yield and the latter 200% more yield than the unmanured wheat in the purely cereal rotation.

Wheat grain and straw in legume rotation were richer in N and K_2O than those from any of the treatments in cereal rotation. The crop in either of the legume rotation removed more N, ash, P_2O_5 , K_2O and CaO than those removed by any of the treatments in the cereal rotation. This showed that there was more mobilisation of nutrients into the crop in legume rotation than in cereal rotation. In the legume rotation wheat in P treated berseem rotation removed more nutrients than those removed by wheat in untreated berseem rotation.

1947-48 *Berseem crop*.—The yield of berseem crop in lysimeter 2 (receiving P_2O_5) was 81% more than that of the crop in lysimeter 1 while the per cent composition of N in P treated and that in untreated berseem crop were the same, the recovery of N by the former was 50% more than that by the latter. P treatment increased the P_2O_5 content in the crop and the total amount of P_2O_5 removed by the crop over the corresponding values of the unmanured crop.

Yield of Wheat

Lysimeter No.	Treatment.			Weight of grain in gms. per lysimeter	Weight of grain in lbs. per acre	Per cent. rise in grain yield
3	O.W.	...	...	188	1605	...
4	N.W.	...	...	292	2491	55.3
5	P.W.	...	...	176	1502	-6.4
6	NP.W.	...	...	439	3747	133.6
7	O.B.C.W.	...	...	557	4754	136.3
9	P.B.C.W.	...	...	713	6086	279.3

Yield of Berseem

1	O	...	...	2426	20705	...
2	P	...	...	4392	36486	81.1

Mineral Composition and removal of Nutrients by Wheat Crop 1947-48.

Lysimeter No.		Per cent. composition of				Removal of Nutrients in lbs. per acre.					
		Ash	N	P ₂ O ₅	K ₂ O	CaO	Ash	N	P ₂ O ₅	K ₂ O	CaO
3	Control	...	0.33	0.092	1.48	0.65	548.3	8.1	2.3	36.8	16.2
4	N	...	0.33	0.052	2.74	0.74	469.0	11.1	1.8	92.8	25.1
5	P ₂ O ₅	...	0.22	0.16	1.93	0.46	329.9	5.1	3.6	34.8	10.5
6	NP	...	0.28	0.128	1.82	0.69	489.2	14.5	6.6	93.6	34.3
7	Wheat after cowpea after untreated berseem	...	0.39	0.1	3.06	0.64	804.4	22.2	5.9	176.5	36.3
9	Wheat after cowpea following P treated berseem	...	0.49	0.13	2.8	1.13	989.7	32.9	8.8	187.5	75.7
3	Control	...	1.42	0.82	0.72	0.14	28.2	21.3	12.2	10.8	2.1
4	N	...	2.1	0.7	0.59	0.15	37.6	28.8	16.2	13.5	3.4
5	P ₂ O ₅	...	1.81	1.07	0.9	0.10	28.4	25.2	14.9	12.5	1.4
6	NP	...	1.99	1.02	1.03	0.11	68.2	69.3	35.3	35.9	4.0
7	Wheat after cowpea after untreated berseem	...	2.72	0.81	0.66	0.097	70.7	191.8	35.7	29.1	4.4
9	Wheat after cowpea following P treated berseem	...	2.37	0.73	0.91	0.14	73.8	132.9	40.8	41.3	7.8
3	Control	...	...	...	...	...	576.5	29.4	14.5	47.6	18.3
4	N	...	...	...	...	...	506.6	59.9	17.9	106.3	28.5
5	P ₂ O ₅	...	...	...	...	...	356.3	30.3	18.5	47.3	11.9
6	NP	...	...	...	...	...	557.4	83.8	41.9	129.5	38.3
7	Wheat after cowpea after untreated berseem	...	...	...	...	...	875.1	142.0	41.6	205.6	41.1
9	Wheat after cowpea following P treated berseem	...	...	...	...	...	1,063.5	165.8	49.6	228.7	83.5

Wheat Straw:—

Wheat grain:—

Grain and straw:—

Foliar diagnosis studies.—72 barley leaf samples from 1947-48 crop from 18 plots of series A of the old permanent manurial series Pusa were analysed for N, P_2O_5 , K_2O , CaO and MgO. The mean intensities and the ratio of N: P_2O_5 : K_2O unit and K_2O :CaO:MgO unit were calculated. Graphs showing the percentage composition of these nutrients at the different dates of sampling were drawn. The N, P_2O_5 , K_2O values were plotted in trilinear coordinates as milliequivalents. The following are the general conclusions drawn.

High yields are associated with (i) Mean intensity values varying between 11 and 12; (ii) The range of optimum for mean composition of N- P_2O_5 - K_2O between 25-34; (iii) Gradual mobilisation of nutrients as could be judged by initially high values with descending curves; (iv) in the trilinear graph the mean N- P_2O_5 - K_2O units of more fertile plots (G.M.+P, F.Y.M. at 8,000 lbs. per acre, rape cake, P and N) fell within the parallelogram defined by the above limits (cited in ii). The corresponding units of less fertile plots (F.Y.M. at 4,000 lbs. NPK, KP, N, K, NK and control plot 13) fell outside the parallelogram.

The exceptions to this general behaviour are control plots 1 and 18 which fell within the parallelogram but the low yields of these plots were attributed to a non-mobilisation of nutrients from the leaf into the plant as could be judged from the rise in the intensity curves (N+ P_2O_5 + K_2O) at the 2nd and 3rd sampling stages.

Table showing the Yields, mean Intensities and mean composition of the N, P_2O_5 , K_2O Units for Barley Crop grown during the Rabi Season 1947-48 in the Experimental Plots O.M.S.-A-Pusa.

(Arranged in the order of yields.)

Plot No.	Treatment.	Yield of (grain & straw) in lbs. per plot.	Mean intensity.	N	P_2O_5	K_2O
16	FYM+P	... 613	11.8	62.7	8.7	28.6
4	F.Y.M. + Rc.	... 488	11.0	63.0	4.8	32.2
15	F.Y.M.	... 484	12.7	64.7	5.7	29.6
3	F.Y.M. (8000)	... 442	9.8	64.6	5.8	29.6
5	R.C.	... 412	11.6	62.9	4.2	32.9
8	P	... 410	11.1	66.7	6.5	26.8
11	N+P	... 408	11.0	65.3	5.4	29.3
2	F.Y.M. (4000)	... 384	10.6	60.6	10.1	29.3
10	N+P+K.	... 348	12.0	59.4	6.2	34.4
9	K+P	... 318	10.8	60.4	10.2	29.4
6	N	... 248	12.1	68.3	3.1	28.6
7	K	... 238	11.6	67.2	4.7	28.6
14	N+K	... 218	12.4	66.8	4.6	28.6
13	check 2	... 170	12.2	67.1	3.9	29.0
1	check 1	... 154	11.5	62.6	6.5	30.0
18	check 3	... 124	11.1	64.8	6.7	28.5

(iv) Micronutrient

1. During the year investigations on the diseases of gram were undertaken to confirm the findings of the last year. "Bronzing" and "Yellowing and Bronzing" plant samples revealed low P_2O_5 content. The figures being 45% and 38% respectively as compared to healthy, the figure of which being 82%. This confirms the last years observations regarding the low P_2O_5 content of the above diseased plants. Top yellowing samples revealed low content of Mn as compared to healthy ones, the figures being 85 p.p.m. of Mn for the diseased and 195 p.p.m. of Mn for the healthy. Further investigations are in progress.

2. Pot culture experiments were laid out with gram using soil of low phosphate content. The treatments were done according to the following plan.

I Series.—P—nill, Mn at 100 lbs. $MnSO_4$ B at 8 lbs. of Boric acid and Mo at 2 lbs. sodium molybdate. The following order was followed:—

P_0 , $P_0 + B$, $P_0 + Mn$, $P_0 + M_0$, $P_0 + B + Mn$,
 $P_0 + Mn + M_0$, $P_0 + M_0 + B$, $P_0 + B + Mn + M_0$.

II Series.—P at 100 lbs. as superphosphate and all other in similar doses as above and according to the above order.

III Series.—Simple treatment of P at 200 lbs. superphosphate.

The experiment was suggested to investigate the occurrence of the Bronzing and other diseases of gram under the above conditions and also to study the uptake of N_2 as affected by the above trace elements.

During the flowering stage Po pots showed symptoms of "Bronzing wilting" or "Bottom yellowing". Here more prevalent at P_{200} treatments. Later all the plants were affected with fungal disease as revealed by the mycological examination.

Estimations of organic N_2 in shoots showed interesting results. Pot treated with Mn showed very high content of N_2 at both levels of P. The figures were 5% and 4.6% of N_2 at P_0 and P_{100} levels as compared to 2 and 2.9% at P_0 and P_{100} levels without Mn. B singly had no effect. Also M_0 at P_0 had no effect. $B + M_0$ at P_0 showed some increase in N_2 , the figures being 3.1 as compared to 2% without $B + M_0$.

3. Indicator plant studies in pot and in field according to Wallace layout were conducted with maize, sunflower and sudan grass in kharif and oats, rape, lettuce and gram in Rabi to investigate the effects of Mn, B, Zn and Mg with N, P, K treatments. The investigation was undertaken in collaboration with soil fertility section and the detailed report is under that section.

(v) Soil Physics

Percolation and permeability of soils.—In order to compare the percolation rates of prepared laboratory soil samples, a standard apparatus was used. To standardise the technique the percolation rates with varying amounts of the same soil, with different degrees of packing were studied. It was found that ten strokes bring out uniform packing of soil. With 140 gms. soil the percolation rate varied erratically and with 280 gms. soil steady and comparable figures were obtained. No additional advantage was gained by using larger amounts of soil. To economise the quantity of soil used for percolation studies, glass tubes of uniform diameter of 1 cm. were packed with 10 gms. of soil and percolation rates were followed under a variable and constant heads of water. It was found that reproducible data could be obtained by this method.

(vi) Physical Chemistry

Plant viruses.—Samples of sunhemp virus and cowpea mosaic virus chemically isolated from the plant were sent for light absorption studies by the Mycology Division. Absorption spectra of virus samples, along with their fine structure components were studied. In the sunhemp virus sample an absorption maximum at $2632\text{\AA}^{\circ}$ due to nucleic acid component and a fine structure component, attributable to tryptophan at 2863OA° were obtained, besides the usual dominant maximum at 2766 OA° . A comparison between the absorption data of three samples showed that there are differences in absorption in the nucleic acid region. Such differences were noticed by Stanley, working with ring spot virus of tobacco and he attributed this to an unstable nucleo-protein which loses different amounts of nucleic acid in the preparation of the different samples of the same virus. The absorption curve of the cowpea mosaic sample showed slight displacement of the characteristic maxima towards the longer wavelengths and also differences in the intensity of light absorption in the-tyrosin-tryptophan region. These observations point out that the sunhemp virus and cowpea mosaic virus strains are not the same and this has been confirmed by negative inter-transmissibility.

(vii) Soil Survey and Land Utilization

I. A. R. I. Farm.—The result of the morphological examination of the profiles studied in plot 11 was discussed in the last years' report (1946-47). Out of these 13 profiles examined 6 profiles were taken up for detailed study in the laboratory.

The laboratory analyses reveals that the soil of this area is sandy loam with clay between 12-22% where sand comprises between 55-83%. The contents of clay decreases slightly with the depth. The carbonate content is very low and is less than 0.5%. The pH varies between 7.5 and 8.4 and is quite optimum for the growth of almost all plants. The soluble salt is less than 0.1% and is at the safe limit. The exchange capacity is between 10.0 and 19 m.eq. and considering the clay content which is also nearly the same the b.e.c. is quite adequate, exchangeable calcium varies from 7 to 20 m.e./100 gms. soil and shows that the saturation of calcium in the b.e.c. is between 63 and 95%. The content of N, P, K of the surface soils only shows that soils are not deficient in these nutrients although the HCl soluble P_2O_5 is only about 0.08%, the available (as determined by citric acid) is about 0.02% thus now nearly 25% of the total P_2O_5 is in the available form.

The soils do not indicate any deficiency either in the chemical constituents or the physical composition and appear to be of more uniform consistency.

The general morphological description of the plots 16 and 17 (Bontany Division) has already been reported in the last year, only the analytical data is discussed here.

The soils are of sandy loam texture. The carbonate content and the base exchange capacity are quite adequate. Over 80 per cent. of the exchangeable bases is calcium and sodium forms 4 to 6 per cent. of the exchange capacity. The ratio of Ca/Na is between 10 to 22 and is very satisfactory. The soluble salts are uniformly low. The available phosphate is high but the total nitrogen is only 0.02 per cent. Water table is at about 4 to 5 ft. and if irrigation is not judicious there is a possibility of the plots getting water-logged.

The analyses data of other profiles collected from plots 14, 15 and 17 of the main block are in general similar to the data discussed already.

In the general classification of I. A. R. I. soils as based on the morphological features of the profiles and on the presence or absence of lime and iron concretions the soils so far studied are tentatively grouped as under:—

- (i) No calcium carbonate in the profile as judged by effervescence to HCl.
- (ii) Presence of calcium carbonate in the profile.
- (iii) No lime in the profile but iron concretions are present; and
- (iv) Both iron and lime concretions present in the profiles, when the complete analytical data of the profiles under the four groups is available, final conclusions will be drawn.

Saline and alkaline patches: Delhi.—In the Institute and farm area moist patches have been noticed and in some plots salt efflorescence and crop failure have been reported. In plot 13 of the Botany Division about an acre of land has deteriorated. Soil profiles from the affected and unaffected areas have been examined in June. The surface soil was generally brown, sandy loam in texture and the texture becomes slightly heavy with depth. The structure was mostly single grain tending to be cloddy at lower depths. A zone of calcium carbonate accumulation at a depth of 55" to 64" was noticed. Roots were seen all through the profile. Moisture content was found to increase with depth and the water-table was met with at about 5 ft. 4 in. In the salt affected areas blue=green patches were noticed here and there, chiefly surrounding the roots. The water that drained and collected at the bottom of the profile pit was sampled. After baling out water the pit was further scooped and ground water samples were collected. The water samples analysed are expressed in parts per 100,000 as below:—

Analysis item.	PROFILE PIT NO. I.		PROFILE PIT NO. II.		PROFILE PIT NO. III.			
	(Affected area)		(Affected area)		(unaffected area).			
	1st	2nd	1st	2nd	1st	2nd		
	sample.	sample. (ground water).	sample.	sample. (ground water).	sample.	sample. (ground water).		
pH.	...	...	8.5	8.2	8.0	8.2	8.1	8.0
T.S.S.	...	...	158.0	154.2	229.0	200.2	42.0	36.8
CO ₃ .	...	...	0.6	nil.	nil.	nil.	0.6	nil.
HCO ₃ .	...	...	14.0	20.7	15.7	20.7	10.4	13.4
Cl.	...	...	73.8	65.3	112.2	100.8	4.3	5.7
SO ₄ .	...	...	5.2	8.6	8.9	4.7	9.4	4.7
Ca.	...	...	11.1	8.0	17.6	12.2	9.4	8.7
Mg.	...	...	2.0	1.4	2.6	2.3	0.8	1.1
Na.	...	...	33.8	35.9	30.7	30.4	11.9	3.7
K.	...	...	2.2	2.5	2.1	4.5	0.96	2.2

The subsoil waters from affected areas show high total salt content, particularly sodium chloride is predominating with low content of divalent cations. The water-logged conditions noticed in the profile indicate bad drainage and rise of saline waters to the surface in the dry periods of the year. Need for judicious irrigation and adequate drainage is indicated. Further analysis of the soil samples is in progress.

Pusa.—The development of alkaline patches at Pusa (sub-station) North Bihar, a soil containing about 40 per cent. CaCO_3 have been reported earlier. The soils at Pusa are recent deposits of silty texture overlying sand at 8 ft. depth. The alkaline patches are mostly fugitive in nature, appearing in winter. Kharif crops grow well but winter crops are damaged. The patches occur at about the same place year after year and a tendency to spread was also noticed. Five soil profiles have been examined in the field and the soils analysed.

In the Pentangular field, the saline area is characterised by the accumulation of clay at lower depths, while in the normal area of the same field the clay content decreases with depth. In the saline area the salt content is 0.28 per cent in the first foot and decreases with depth. In the normal area at 56"-61" there is a zone of salt accumulation of total salt content 0.62 per cent. The area is particularly rich in soluble salts of sodium chiefly Na_2SO_4 . Though calcium forms the predominant exchangeable base in the profiles from uncultivated, cultivated and orchard plots, in the profiles from Pentangular field magnesium saturates the exchange complex to a greater extent than calcium, and sodium forms over 25 per cent. of the exchange capacity.

Sind.—Sind profiles from Kalar affected areas at Larkana and Sakrand in Sind were obtained through the courtesy of Dr. Mirchandani. At Larkana the soils are heavy with a clay content of 40 to 70 per cent. in the surface soil and generally decreasing slightly with depth. The soils contain nearly 10 per cent. CaCO_3 and the pH is round about 8.0. The whole area is a paddy growing tract, with subsoil water table near about 4 ft. The soils in the Sakrand tract are mainly loams, generally calcareous, mildly alkaline and the water table is at 20 to 50 ft. in different parts. Profiles from Larkana farm cultivated field showed a high per cent. of total salt (0.52 per cent.) at the top, decreasing with depth and 4' to 6' depth there is an accumulation zone of salt (0.75 per cent.), the predominant salt is Na_2SO_4 . The exchange capacity is low in spite of the high clay content and over 25 per cent. of the exchange capacity is sodium. Sodium content of the exchange complex decreases with depth. In the uncultivated area the salt zone occurs at 1 ft. to 2 ft. depth and the complex is highly sodiumised. In the Sakrand profile, which is loamy, the salt concentration is uniformly high and degree of alkalisation increases with depth.

Rapid Reconnaissance Survey: Jubbulpore.—The survey carried was of the reconnaissance type and in all eleven profiles scattered all over the area were examined morphologically and samples collected. A detail topographical survey was also carried of the whole area.

From the examination of soils in the field it appears that there are mainly three series of soils (1) A black soil to a depth of more than 6 ft. without any marked change in the horizon except the presence of lime kankar; (2) A black soil to a depth of about 4 ft. and immediately below it occurs a reddish brown soil and; (3) A greyish black soil without any change in colour throughout the profile.

Morphological examination.—The general morphology of these soils in the field show that these soils are quite deep, deeper than 6 ft. and are heavy in texture. Since the examination of these soils was carried out in dry months these soils showed innumerable deep cracks, reaching upto a depth of 6 ft. or more in some cases, except in the soil where brown layer is met, the cracks do not go beyond this horizon. The structure in most of the cases was cloddy. The soils showed strong effervescences with dilute HCl only when pieces of lime kankar were met. There was no perceptible evidence of soils being affected by the salt. The external drainage as judged by the nature of relief and the internal drainage as seen by the depth of the root penetration show that both are quite free.

The typical profile features of the above three series of soils are as follows :—

Pit 4.

Depth.

- 0-36" Black colour, clayey texture, sticky consistency, mixture of black and white concretions with few gravel pieces, roots present (more in 0-12") massive structure, slight effervescence on the top.
- 36-48" Same as above except that lime nodules are of bigger size and are abundant.
- 48-78" The colour (black) is getting mixed up with whitish yellow patches, massive structure, slight effervescence.

Pit 1.

- 0-51" Black colour, clayey, wet, massive structure, thin roots present, black concretions present, sticky consistence, at the 4th feet the soil is mixed with reddish colour, soil giving a chocolate tinge, no effervescence with dilute HCl. Thin roots are present upto the lower end of the layer, compact layer.
- 51-77" Brown colour with reddish tinge, clay loam in the top portion with light texture in lower portion, no effervescence with dilute hydrochloric acid, no black concretions present, no roots present, moist but not sticky as above. Lowest.

Pit 7.

- 0-12" Blackish grey colour, clay loam texture, cloddy structure, cracking but not very much and only thin cracks are seen, profuse black concretions hard consistency, not very moist, effervescence only when lime nodules are met. A few lime kankars present, roots present.
- 12-48" Same as above except more presence of lime kankars.
- 48-72" Same as above but more moist.

The laboratory analyses.—All these three series soils are clayey, the clay content varies between 44 and 47% except in the 1st series where the lower horizon at a depth of 51-77" has only 26.0% clay, the sand in the first series is between 35 and 38% except in the lowest horizon where it is 58%, while silt is only between 16 and 18%. In the second series the sand is between 30-33% and silt is between 29 and 23%, whereas in the third series sand is about 28% and silt is also of the same order. Although there is not much variation in the clay content in these three series yet the proportion of sand and silt differs in each series. Carbonates in the first series is decreasing with the depth while in second series it is increasing and from the morphological description it appears that there are large kankar pieces at the lower depth, while in the third series carbonate are more in the upper layer. The carbonate content in the first series are about 1 to 2% in upper layer with only 0.1% in the lower horizons. In the second series it is between 1 to 3% while in the third series, it is 1 to 5% highest being at the top, the soil reaction in the first is neutral while second and third series it is mildly alkaline. All these series are low in the nutrient status as N, P and K are about 0.03%, 0.05% and 0.4 to 0.6% respectively. The b.e.c. capacity of these soils is fairly well and is of the same order in all the three series which varies 30-39 m.e./per gm. soil, the exchangeable Ca in series second and third are of the order of 33 to 35 m.e. while in the first series it is about 25 m.e. Further work is in progress.

Rann of Cutch.—In a very rapid reconnaissance survey to assess the suitability of the Rann area ($22^{\circ}45'$ to $24^{\circ}45'N$ and $68^{\circ}26'$ to $71^{\circ}45'E$) for agricultural purposes, soil profiles in widely separate areas have been examined and soil samples were analysed. The nearest place name is prefixed to the profile to indicate its origin. The range of clay, silt and sand and total soluble salt contents in the profiles is indicated below:—

Profile	Clay. %	Silt. %	Sand. %	Total soluble salts %.
Gonthana. ...	22 to 38	11 to 34	5 to 17	9 to 17
Nanda. ...	17 to 48	12 to 44	4 to 44	6 to 11
Lakhpat-Piprala. ...	37 to 44	14 to 38	7 to 33	6 to 8.6
Bela. ...	23 to 44	15 to 50	5 to 20	6.4 to 12.4
Kavda (barren area) ...	7 to 24	4 to 26	27 to 77	3 to 9
Kavda (camel bush area). ...	23 to 37	28 to 44	9 to 40	2.3 to 3.9

The profiles from the different areas which are alluvial in origin, while showing differences in detail, have common features. The surface soils are brown or dark brown in colour, silty clay in texture, which generally changes to a lighter texture with depth. In some of the profiles well developed columnar or prismatic or laminar structures could be distinguished. Glei horizons are noticed in the profiles and in one profile the glei horizon is as near to the surface as 12" and extends to 43" depth. Gypsum in fine crystal size occurs generally in all the profiles and in one profile crystalline deposits of gypsum in lens shaped druses, irregular shaped and as selenite rods have been noticed. Water table is found to vary from 27" in the Rann area near to the sea to about 90" at other places.

The pH of the soils is round about 8.0. The soluble salt content of the soils is high and apart from gypsum, consist mainly of sodium chloride, carbonates are practically absent and the bicarbonate is uniformly low. The salt content generally decreases with the depth of the profiles. It is also noticed that the gypsum concentration occurs at a lower depth in the areas inundated by river water, while in the areas reached by sea water, the maximum quantity is found in the first foot.

The soils are considered reclaimable. Though the rainfall in the area is low considerable quantities of flood waters are available for reclamation work. The economic possibilities of winning gypsum and salts will reduce the cost of reclamation work.

Further work is in progress.

Cartography.—During the year under report the section has been adequately equipped with survey and cartography instruments.

When the Institute was started in 1936, the land which was gullied and broken up, was drastically levelled and laid out into plots. A topographical survey of the present layout was carried out during this year. A map showing extent of earth removal or filling up from levelling the farm area has been prepared on a scale 12"=1 mile. This map is likely to prove of great value in interpreting the soil analysis data and the results of experiments conducted on these plots.

Topographical survey of the Karnal Substation, has been completed and the maps are under preparation.

The following climatological and vegetation maps of India were compiled from the published data:—

- Map of India showing summer, winter and mean annual rainfall.
- Map of India showing mean minimum, mean maximum and mean annual temperature.

Topographic maps and present land use of Jubbulpore and Rann of Cutch were also compiled.

Nothing to report.

(1) Nitrogen transformations in soil

(2) *Study of Root Nodule Organisms.*

Table showing fixation of atmospheric nitrogen by different cultures of Urid nodule bacteria.

			Culture No.	No. of Plants	No. of Nodules	Dry wts. gms.	Total Nitrogen mg.	Nitrogen in seeds Sown mg.	Nitro- gen. fixed. mg.
1	culture	Urid	...	3	7	106	0.93	25.06	10.92 + 14.14
2	"	"	...	5	8	55	0.63	19.18	12.48 + 6.70
3	"	"	...	6	9	115	1.23	37.38	14.04 + 23.34

Residual effect of different levels of super phosphate on leguminous crop (pea).

Plots were manured with superphosphate at the rate of 60 lbs. and 120 lbs. P_2O_5 per acre in November 1946 and a crop of pea was taken. In 1947 maize was taken and followed by pea. The residual effect of superphosphate as shown by the yield and the nitrogen content of the crop is shown in the following table.

The average yield and composition of pea per plot is shown in the following table.

Average results of four observations.

Treatment		Yield of pea seed oz	Increase over control	Total N in seeds oz	Increase over control	Total P_2O_5 in seeds oz	% increase over control
Control	...	16	...	0.665	...	0.078	...
60 lbs. P_2O_5	...	29	81.2%	1.217	83.0%	0.165	112%
120 lbs. P_2O_5	...	32	100.0%	1.338	101.0%	0.223	186%

These results show a marked influence of P_2O_5 even in the 3rd crop.

Influence of different types of phosphatic fertilisers on the formation of nodules and fixation of nitrogen by leguminous crops.

The following phosphates were selected:

Superphosphate, Bone-meal, Trichi nodule and Singhbhum phosphate. The crop selected was pea. The crop was examined when the plants were 12 weeks old for its chemical constituents as well as for the development of nodules and their composition. The crop and the soil were examined when the crop was harvested.

Table showing the effect of different phosphates on the formation of nodules and nitrogen content of 12 weeks' crop of pea.

		Control gms	Super- phosphae gms.	Bone- meal gms.	Trichi nodules gms.	Singhbhum phosphate gms.
Weight	...	17.53	22.16	21.13	19.30	19.33
<i>Tops</i> Increase over the control	...	...	26.4 %	20.6 %	10.1 %	10.3 %
Weight	...	4.43	4.10	4.24	3.75	4.04
<i>Roots</i> Increase over the control	...	...	-7.4 %	-4.3 %	-15.3 %	-8.8 %
Weight	...	0.19	0.31	0.27	0.31	0.30
<i>Nodules</i> Increase over the control	...	...	63.2 %	42.1 %	63.2 %	57.9 %
		mg	mg.	mg.	mg.	mg.
Total Nitrogen in mgms.	...	11.4	17.29	18.52	21.09	19.66
Increase over the control	...	...	51.13%	61.89%	84.35%	71.85%
Total P_2O_5 in mgms	...	2.07	3.01	3.29	3.35	3.60
Increase over the control	...	...	45.41%	58.93%	61.83%	73.74%

These results show that the pea is capable of making use of indigenous insoluble phosphates though to a somewhat less extent as compared to super phosphate.

Similar results, as will be seen from the following table, were obtained when the crop was examined after maturity. As the crop had matured and dried the question of examination of nodules did not arise. The nitrogen content of the crop and soil was examined.

Effect of different Phosphates on the Fixation of Atmospheric Nitrogen through Legumes.
(Pea N.P. 29). 120 lbs. P_2O_5 per acre basis were applied to the Pots.

(These results are based on the average of 4 pots.)

Treatments.	Yield of crop seed	N per Kilogram of soil.	N in crop (2) compelled per Kilogram of soil.	Total N in crop and soil	Increase over the control	Increase over the cropped control	N fixed per acre (3) 10" of soil.	N fixed per lb. of P_2O_5
	gms.	mg.	mg.	mg.	mg.	mg.	lb.	
Control uncropped	...	422.5	...	422.5	...	...	...	...
Control cropped	31.00	427.5	71.2	498.7	76.2	...	...	...
Superphosphate	38.02	435.0	87.2	522.2	99.7	23.5	78	.65
Bonemeal	32.83	458.0 (1)	70.4	528.4	105.9	29.7	99	.83
Trichi Nodule	35.00	432.5	77.7	510.2	87.7	11.5	38	.32
Singbhum phosphate	37.48	427.5	81.6	509.0	86.6	10.4	35	.29

(1) N added in the form of Bonemeal deducted.

(2) N of the seeds sown has been deducted.

(3) The pots contained 10" of soil.

Statistical analysis carried out on the basis of nitrogen fixed, showed the following order:—

D C E F B A where A = Control uncropped

B = Control cropped.

C = Superphosphate.

D = Bonemeal.

E = Trichi nodule.

F = Singbhum phosphate.

The above figures show that if indigenous phosphates are used for manuring leguminous crops we can increase the nitrogen fixing power of the legumes though to a less extent than with superphosphate. This suggests that if the amounts of indigenous phosphates for manuring are increased without increasing the cost to the level of cost of superphosphate we might get better results. Further experiments will be conducted in the next rabi season. Bonemeal has comparatively given low yields but so far as the nitrogen fixation is concerned it has been found to be the best. The residual effect of bonemeal often observed may probably be due to its N fixing power. The yield alone should not be the criterion in judging the fertilizing value of bonemeal but its nitrogen fixing power should also be taken into consideration.

(3) *Nitrogen fixation Scheme of I. C. A. R.*

According to plan two assistants were to be appointed but only one meant for bacteriological and chemical work could be recruited. The other meant for studying the wild leguminous plants could not be appointed as yet and thus this part of work could not be taken up.

The Assistant appointed for chemical and bacteriological work devoted his attention towards the isolation of efficient strains of root nodule organism of Rahar and Gram.

The seeds of rahar were obtained from our Botanical Substation, Pusa and that of gram from the Division of Botany Delhi. In order to eliminate the possibility of organisms of one locality being transferred along with seeds to other localities the seeds were first sterilized and then sown at Delhi, Karnal, Pusa and Coimbatore. All the places were visited by the assistant and the root nodule organisms of both the crops were isolated. Thus there are 10 strains in hand. Their efficacy will be tested by inoculating the respective seeds in the coming season. In a trial pot culture experiment rahar inoculated with Delhi strain gave the following increases over the control (uninoculated):— tops 1.69 per cent, roots 2.80 per cent., weight of nodules 2.79 per cent, number of nodules 16.9 per cent. Increase in total N in tops, roots, and nodules was 10.2 per cent.

The following observations of interest were noted. In the case of gram nodulation goes on increasing even upto the flowering stage but in the case of rahar, nodules appear only in the earlier stages of growth, in later stages probably the crop being a deep rooted one feeds on soil nitrogen. Another possibility is that the upper portion of the roots become hard and do not bear root hairs through which the organisms gain entrance.

Gram grown at Coimbatore in red soil did not bear nodule but those in black soil did though they were smaller and less in number than those found at Pusa and at Delhi.

Another interesting feature in the case of rahar was the effect of phosphate manuring. Rahar grown in our experimental area was bearing profuse flower some of which were being shed. It was thought that perhaps the soil needs phosphate. Half the plot was, therefore, manured with superphosphate at the rate 120 lbs. P_2O_5 per acre at a flowering stage. It was found that the treated plots gave an increased yield of 44% seeds over the control.

(4) *Fuel gas and anærobic fermentation of F.Y.M.*

Plot experiments conducted with anærobically fermented F.Y.M. gave the following results which are based on the average results of 4 plots.

	Yield of grain per plot.		Increase over the control.	
	Lb.	oz.	Lb. — oz.	%
A Control.	1	13	0 0	
B F.Y.M. from heap	2	3	0 6	20.7
C Anærobically fermented F.Y.M. fermented by loading 10 lbs. cow dung every day and taking out after a fortnight.	2	9	0 12	41.4
D. do. do. fermented by loading 150 lbs. fortnightly	2	7	0 10	34.5

These results show that anærobically fermented farm yard manure is superior to ordinary F.Y.M. The amount of manures applied were:—

N-80 lbs. per acre over a basal dose of 40 lbs. P_2O_5 per acre as superphosphate.

(5) *Disease of gram.*

Disease characterised by bronzing of leaves followed ultimately by the death of plant. Diseased and healthy plants were examined at the different stages of infection.

It was found that the diseased plants contained less number of nodules than the healthy ones.

It was also found that the soil near the diseased plants contained a little more nitrite than the soil near the healthy plants.

(6) *Manufacture of Gur and Sugar from Palmyra Palm juice with special reference to control of fermentation.*

Preliminary observations on the yield of juice per tree were taken and gur was manufactured. It was found that on an average a male tree yields 11.3 lbs. juice per day while a female tree yields 14.8 lbs. of juice. A tree yields twice as much juice at night as during the day. The average sucrose content of the juice from a male tree is 11.96% whereas the average from a female tree is 10.15%. Number of antiseptics were tried to control fermentation, of those formalin gave good results. It is lost during the evaporation of juice for the manufacture of gur and the gur manufactured was found to be better than that from the juice treated with lime.

(x) *Biochemistry*

Mineral assimilation from different fodders by high milking Sahiwal cows.—The experiment was conducted in the year 1946-47, the samples of milk, feces, urine, fodders and the grain mixture were preserved after oven drying or ashed and solution in HCl prepared. The analytical work is nearing completion. About 100

samples out of the 550 samples collected remains to be analysed. The following was the plan of the experiment (Latin Square). Four fodders and four cows were used.

Cows.					Fodders.	
		1			A	Unmanured berseem.
		2			B	Manured berseem.
		3			C	Lucerne.
		4			D	Jowar silage plus hay.
1	A	B	C	D	Calcium, magnesium, sodium, potassium, phosphorus and chlorine were determined in the feces and outgo.	
2	B	C	D	A		
3	C	D	A	B		
4	D	A	B	C		

Each period consisted of 12 days out of which six days were experimental and six days non-experimental.

The following conclusions have been arrived at:—

- (1) Green fodder as compared to hay or silage do not change the mineral composition of milk.
- (2) The assimilation of calcium and phosphorus is better from the green fodders, than hay or silage.
- (3) The assimilation of phosphorus was higher from manured berseem than unmanured berseem.
- (4) The assimilation of calcium is better from the legume fodders than non-legume fodders.
- (5) Berseem manured with Ammonium phosphate is richer in phosphorus contents than unmanured berseem.
- (6) The rations without any mineral or bonemeal supplement are not sufficient to maintain positive phosphorus balances in the cows.

High milking cows loose phosphorus during the period of flush if the rations are not supplemented with mineral phosphate salt or bonemeal.

Further work is in progress.

II.—ADVISORY

During the year 2,307 samples were registered and 447 samples of the following descriptions were analysed and reported during the course of advisory work to various institutions in addition to analytical work undertaken in connection with research problems of the Division.

Soils	...	...	...	...	...	...	...	157
Manure	...	...	...	...	...	...	...	17
Fertilizer	...	...	...	...	...	...	...	7
Crop (grain & straw)	...	...	...	...	...	...	...	58
Leaves	...	...	...	...	...	...	...	50
Feeding stuff	...	...	...	...	...	...	...	51
Fodder	...	...	...	...	...	...	...	60
Water	...	...	...	...	...	...	...	6
Tobacco	...	...	...	...	...	...	...	7
Gur	...	...	...	...	...	...	...	21
Plant	...	...	...	...	...	...	...	6
Miscellaneous	...	...	...	...	...	...	...	7

(a) Analysis of some of the routine samples of general interest may be mentioned.

A mixed fertiliser called "Manurin" manufactured by a Calcutta firm in the form of tablets of 5 grains has the following composition:—N—6.4%; P_2O_5 —22.19%; K_2O —24.79%; CaO—0.31%. These tablets are recommended for use in flower pots and on fruit trees.

A sample of town refuse manure collected from the Delhi Municipal refuse dump was found to contain N—0.9%; P_2O_5 —1.6%; K_2O —2.27%; CaO—6.12%. A huge quantity of this material is available and is being utilised by cultivators.

A patented preparation called the 'Q. R. Compost Maker' manufactured by a British firm was received for trial from the Ministry of Agriculture. The material on analysis gave moisture 7.13%; loss on ignition 79.38%; N—2.32%; P_2O_5 —0.85%; K_2O —2.91%.

It is claimed by the manufacturers that one teaspoonful of this material diluted in one pint of water can convert one ton of refuse matter into good quality compost. The analysis however does not justify the claim. Actual trials have also proved unfruitful.

(b) *Supply of bacterial cultures*.—Cultures of gram or berseem were supplied to:—

- (1) Mycological assistant Govt. of Assam.
- (2) Director of Agriculture, Ajmere.
- (3) Sir Dattar Singh.
- (4) Deputy Director of Agriculture, East Punjab.

III.—PROGRAMME OF WORK (1948-49)

I.—AGRICULTURAL CHEMISTRY (Manurial experiments)

1. Following collaborative field experiment trials with the Division of Agronomy to obtain confirmatory data regarding beneficial residual effects of phosphate manuring of legumes on the subsequent yield of wheat:—

- (i) to study to what level berseem treated with phosphates and followed by guar for 3 years builds up soil fertility.
- (ii) to study the effect of heavy doses of complete fertilizers (N, P and K) without legumes in building up soil fertility for comparison with (i) above.
- (iii) to compare the effect of introducing a legume like peas in rotation with wheat and maize with the results of (ii) above.
- (iv) to study the possibility of building up soil fertility by means of organic nitrogen in the form of oilcakes and green manures and to study their rate of decomposition under field conditions.

2. Water analyses including periodical examination of well waters in the Indian Agricultural Research Institute.

3. Analyses of manures, fertilizers, feeding stuffs, etc.

II.—SOIL CHEMISTRY

4. Methods of soil analysis.
5. Analysis of soil samples.

III.—SOIL FERTILITY

6. Study of the mineral deficiencies (major elements) using indicator plants and comparison with other methods.

7. Plot experiments—the effect of phosphatic fertilizers on soil fertility.
8. (a) Phosphorus fixation in relation to soil fertility (estimation of total and available phosphates in the permanent manurial plots and berseem experiment plots in Delhi).
(b) To study the rate curves of phosphate solubility of different typical soils with various solvents.
9. Effect of N/P ratio on the growth and quality of crops with special reference to leaf curl disease of tobacco.
10. Studies on soil colour in relation to plant growth.
11. Studies on the nutritional level of plants grown in manurial plots by tissue analysis

IV.—MICRONUTRIENT ELEMENTS

12. Comparison of the microchemical and spectrochemical methods of analysis.
13. Diagnosis of micronutrient deficiencies using indicator plants and injection methods.
14. Study of minor element deficiency diseases with reference to citrus (Indian Council of Agricultural Research Scheme).

V.—SOIL PHYSICS

15. Studies on porespace, pF, water-holding capacity and permeability of typical soils.

VI.—PHYSICAL CHEMISTRY

16. Phosphate fixation by soils.
17. Studies on the chemical, electrochemical and viscous properties of colloidal constituents of soils obtained from different horizons of black cotton soil profile (Indian Council of Agricultural Research Scheme).

VII.—SOIL SURVEY

18. Survey of the Farm areas under Indian Agricultural Research Institute at Delhi. Pusa, Karnal and other selected places.

VIII.—PLANT CHEMISTRY INCLUDING SOIL ORGANIC MATTER

19. Studies on the organic matter of soil and organic phosphates.

IX.—MICROBIOLOGY

20. Reversion of phosphoric acid through soil micro-organisms.
21. Influence of one crop upon another with special reference to the part played by root secretions and micro-organisms.
22. Nitrogen transformation in soil.
23. Influence of different types of phosphatic fertilizers on the formation of nodules and on nitrogen fixation by different legumes.
24. Study of efficient strains of root nodule organisms.
25. Study of gram wilt disease in collaboration with different sections of this division and divisions of Mycology, Botany and Agronomy.
26. Study of wild leguminous plants and of pulses.

Report of the Head of the Division of Entomology

I.—INTRODUCTORY

Dr. E. S. Narayanan took charge of the Division of Entomology on 1st August, 1947, in addition to his own duties as Biological Control Research officer from Dr. Taskhir Ahmad who opted for Pakistan. He joined as Officiating Head of the Division on 22nd June, 1948. Mr. C. K. Samuel and Mr. B. B. Bose continued to officiate in the two posts of Assistant Systematic Entomologists. Dr. S. Mukerji whose post of Assistant Entomologist was converted into the post of Assistant Insect Physiologist took charge of the post of the Biological Control Research Officer on 27th March, 1948. He was appointed to the post of Systematic Entomologist on 17th June, 1948. Dr. R. Menon, Officiating Assistant Entomologist, Population Studies left for England on foreign scholarship. Dr. S. Pradhan returned after foreign training in toxicology and joined his post of Assistant Entomologist, Population Studies, which has now been designated as Assistant Insect Epidemiologist. He subsequently joined the post of Toxicologist on 21st June, 1948. Mr. T. V. Venkatraman joined the post of Assistant Sugarcane Entomologist on 11th August, 1947.

The scheme for the Biological Control of Sugarcane Pests financed by the Indian Central Sugarcane Committee continued to operate throughout the year. The schemes on pests of stored jowar and pulses financed by the Indian Council of Agricultural Research terminated on 30th September, 1947, and thereafter the work was taken up as part of the activities of the main Division. The scheme for the standardization of technique for the fumigation of imported fruits terminated on 31st March, 1948, and fundamental research on this aspect of the problem was also taken up by the main Division.

The training of the post-graduate students for the Diploma of Associateship of the Institute was continued and three were trained during the year under report. Six students completed their course in Plant Protection and Quarantine. Out of the four Research Fellows admitted to work on systematics, two finally opted for Pakistan and left the Division.

II.—REPORT ON INVESTIGATIONS

1. *Insect population studies*.—The long term project of the collection of biotic and climatic data on population fluctuation of spotted bollworms of cotton with the ultimate view of analysing the factors which govern the occurrence of insect epidemics was continued.

The problem consisted of three essential parts, *viz.*—(a) field census, (b) field rearing and (c) meteorological observations. The first two items were continued as usual without any serious break but as regards the meteorological observations, the costly self-recording instruments, *viz.*, the thermohygrograph and the hyetoevaporigraph had to be removed later in the season due to the influx of refugees in the vicinity of the plot and their tampering with the Stevenson Screen. Thus the meteorological observations consisted of the maximum and minimum temperatures and the relative humidity recorded twice daily at 8-30 and 14-30 hours. The data collected are yet to be compiled and analysed.

During the year, the population of both the species of spotted bollworm (*E. fabia* and *E. insulana*) followed the same trend of rise. Whereas the population of *E. insulana* reached its peak in the second week of September, the peak of *E. fabia* was noted in

the 1st week of December. The population of both the species was reduced to the minimum in the month of February. It began to rise again in the beginning of April and the peak of both the species together was observed in the 1st week of May.

The population of pink bollworm remained comparatively much lower than that of spotted bollworm except during the period February to April. The population rose at the end of October and the peak was reached in the last week of December.

2. *Biological Control of insect pests—*

- (i) *Field survey of sugarcane Pests and their natural enemies.*—Observations made in the field during the period under report showed that the most important borer damaging sugarcane in Delhi was the top borer, *Scirpophaga nivella*, as in the previous year. The incidence of this borer was at its peak during September-December, when about 15% of the shoots were found attacked. The incidence of *Pyrilla* was low throughout the period under report. Among the natural enemies, *Melcha ornatipennis*, the larval parasite of the top borer, was active from July to October and an average parasitisation of 4% was observed.
- (ii) *Mass breeding of Trichogramma evanescens minutum.*—During the period under report about $3\frac{1}{2}$ lakhs of moths, 800 c.c. of eggs and about 12 million parasites were bred in the parasite laboratory. Cultures of host and parasites were supplied to centres when there was a break down in breeding in those localities.
- (iii) *Studies on the longevity and fecundity of Trichogramma evanescens minutum.*—Experiments carried out on the longevity and fecundity showed that (1) The average longevity of the mated parasites which were not allowed to oviposit and fed on crushed *Corcyra* eggs (1 gm. in 10 c.c. of water) mixed with 10% glucose solution, in equal proportions, was 2.83 days in cases of males and 3.47 days in case of females, (2) The average longevity of the parasites when allowed to mate and lay eggs on their host, and fed on crushed *Corcyra* eggs (1 gm. in 10 c.c. of water), mixed with 10% glucose solution, was 2.4 days in case of males and 7.5 days in case of females. The females under the above conditions were capable of laying on an average about 69 eggs, the maximum laid by a female being 176, (3) The average longevity of the unmated parasites fed on crushed *Corcyra* eggs (1 gm. in 10 c.c. of water, mixed with 10% glucose solution) was 7.6 days and 3.7 days in the case of females and males respectively, (4) The virgin males and females when fed on plain tap water, lived for a maximum period of 88 hours and 240 hours, respectively, with an average of 2.25 days and 2.57 days respectively and (5) The average longevity of mated parasites in the absence of its host and fed on tap water only was 1.27 days in the case of males and 1.14 days in the case of females.
- (iv) *Studies on the effect of different intensities of light on the reproduction of Trichogramma evanescens minutum.*—Oviposition experiments carried out under different intensities of light, in shade, outside the parasite laboratory, showed that light was an important factor in governing the activity of *Trichogramma*. The parasite activity was at its minimum in the early hours of the morning during the cold months (October-December).
- (v) *Mass breeding of Bracon (Microbracon) gelechiæ.*—The mass breeding of the parasite on the alternate laboratory host, *Corcyra cephalonica* progressed satisfactorily throughout the period under report and an average of about 5,000 parasites per month, were produced.

(a) *Development of mass breeding technique*.—Experiments were carried out to find out the optimum breeding conditions for the production of maximum number of parasitised larvæ yielding a maximum number of adults per host larva. It was found that superparasitism as a result of overcrowding of adult parasites in the oviposition cage, was one of the causes of low rate of breeding. It was also observed that the number of parasite grubs which shared a single host had a direct bearing on the sex ratio and mortality of the parasites, *i.e.*, as the number of parasite grubs which shared a host increased, the number of males increased and also the size and vigour of individuals bred decreased.

(b) *Factors in host selection by Bracon (Microbracon) gelechiæ*.—Experimental studies to find out the tropic responses of the female parasite to sensory impressions awakened by the host, relative to its shape, size, texture, odour, etc., showed that (1) the selective powers of in the species is highly marked, *i.e.*, when no choice is offered the females exercise restraint and reject hosts already parasitised, (2) oviposition response is in some way related to the quantity of host material present and (3) when a choice is given, the parasite prefers its natural host *Gnorimoschema operculella* to the alternate host (*Corcyra cephalonica*).

The above findings are of great practical importance in the propagation of *Bracon gelechiæ*.

(c) *Trials with alternate laboratory hosts*.—Two important and significant observations were made during the course of experimental parasitism. The top-borer larvæ *Scirpophaga* and the larvæ of the maize stem borer *Chilo zonellus* were parasitised by *Bracon gelechiæ*. The larvæ of *S. nivella* were readily accepted by the female parasite when exposed under muslin and as many as 9 to 12 eggs were laid on a single caterpillar. The maximum number of adults bred per host was 7, with an average of 5 adults per host. Laboratory trials showed that the female parasite was capable of parasitising top borer larvæ which were near the exit holes, while those which had receded far into the tunnel, escaped parasitisation. Similar laboratory observations with *Chilo zonellus* were under progress.

- (vi) *Possibilities of mass propagation of Stenobracon deesæ and Telenomus beneficiens*.—A good alternate host was found in the maize borer, *Chilo zonellus* for the multiplication of *S. deesæ*. It was found that it is possible to store *C. zonellus* larvæ at a temperature of 10°—13° C. in large numbers and use them whenever needed for the multiplication of the parasite.

Eggs of *Corcyra cephalonica* were sprayed with larval and egg extracts of the top-borer, *Scirpophaga nivella* and exposed to *Telenomus* in different ways. No results have so far been achieved. Further trials on the eggs of the wax moth *Galleria melonella* have not given any conclusive results.

- (vii) *Trichogramma colonisation field experiments at Cuttack & Orissa*.—As a result of the parasite liberations a maximum parasitisation of 100% was observed in the experimental plots in most of the observations from July to September while the parasitisation in the control plots was mostly below 25% and in a few cases reaching up to only 40%. In October the parasitisation in the experimental plots was also 100% against only 8.7% in the controls.

The borer population at the time of harvest per acre was 227, 202 and 389 in the six liberation, twelve liberation and control plots respectively. The average yield of cane per acre was 648.9 mds., 710.6 mds. and

546.3 mds. for the six liberation, twelve liberation and control plots respectively.

The experiments laid out for the year 1948-49 are in progress.

- (viii) *Field experiments on the biological control of Pyrilla (Karnal).*—The *Pyrilla* parasite conservation experiments were repeated at Karnal in two different sets of six blocks of half and one acre each respectively.

The egg parasitisation in the conserved, stripped and control plots of the one acre plots before conservation and stripping was 1.604%, 0.82% and *nil* respectively. After conservation and stripping no parasitisation in the eggs of *Pyrilla* was noticed in any of the plots. In the half acre plots the initial parasitisation was less than 1%. Before conservation and stripping the parasitisation in the conserved, stripped and control plots was 16.59%, 11.19% and 5.96% and after conservation and stripping the respective figures were 12.68%, 1.28% and 8.67%. The yield of cane from these plots were 4,595 lbs., 3,791 lbs. and 3,214 lbs. for the conserved, stripped and control plots of the first set. Similarly the figures for the second set were 2,525 lbs., 2,703 lbs. and 2,098 lbs. respectively.

- (ix) *Field experiments on the control of Pyrilla by Epipyrops melanoleuca.*—While observations on the population of the pest were made frequently, no attempt could be made to collect *Epipyrops* from different places due to the grave disturbances that broke out in September and October.

- (x) *Field experiments for the control of tob-borer, S. nivella by telenomus beneficiens.*—The egg-masses that were laid in the experimental plots were collected and kept in the laboratory under observation for the release of parasites, if any emerged. The parasitisation was very low and no conclusion could be drawn.

3. Pests of stored foodstuffs—

- (i) *Pests of jowar.*—Observations on the storage pests of jowar in the month of October 1947 showed that at 0° C. the adults of *Rhizopertha dominica* became inactive but became active when exposed to room temperature. The optimum temperature for *R. dominica* was between 31° C. and 36° C.

(a) *Biology.*—Detailed observations on the biology of the chalcid larval parasite of *Bruchus* spp. were pursued in the laboratory under controlled conditions of temperature (78°-82° F.) and humidity (50-65%). The eggs (0.5 mm. × 0.25 mm.) are translucent white, spindle-shaped, broadly rounded at one end and tapering towards the other end. The incubation period varies from 26 to 45 hours. The parasitic grub on emergence feeds on the host body. The grub stage lasts on an average 7-8 days. The female pupa is slightly larger than the male pupa. The pupal stage lasts 8 days on an average. The longevity of the adult parasites is about 60-70 days when fed on raisins. Freshly pupated grubs of the bruchids are also parasitized.

(b) *Breeding of Bruchids in pulses.*—Observations on the extent of *Bruchus* infestation in pulses (broken and whole) have shown least damage when they are stored in broken condition. Milling the pulses reduces the moisture content of the grains as well as the pupating space required for the development of the insect. Further, by storing the pulses with a uniform layer of husk or skins (4"—5" deep) on the top in airtight containers, the damage could be reduced.

- (ii) *Pests of dry fruits.*—From a series of preliminary experiments carried out with methyl bromide fumigation during the previous year by using different dosages

and exposures, the results showed that a dosage of 1 lb./1,000 cubic feet for $1\frac{1}{2}$ hours gave cent per cent kill of *Oryzæphillus surinamensis* and 1 lb./1,000 cubic feet for 2 hours gave similar result for adults and larvæ of *Tribolium castaneum* under atmospheric temperature, e.g., 87°-95° F. and 80-100% humidity. Again, under above conditions a dosage of $1\frac{1}{2}$ lbs./1,000 cubic feet of methyl bromide for 1 hour was lethal to *O. surinamensis* and a dosage of $1\frac{1}{2}$ lbs./1,000 cubic feet for $1\frac{1}{2}$ hours was lethal to *T. castaneum* in the case of larvæ and adults of both the species. Experiments were continued during the year under report at lower temperatures, and it was seen that for lower temperature either a longer exposure or a higher dosage than the above is necessary to be lethal. When dried fruits like cashewnuts, walnuts and almonds with their outer skin removed and infested with *T. Castaneum* were fumigated with methyl bromide, they invariably acquired a pink colouration. On the other hand when the infestation was due to some other species, the nuts did not acquire any colouration. These observations indicate that methyl bromide is not a suitable fumigant to be used in the case of dried fruits like nuts when infested with *T. castaneum*.

4. Insect vectors of virus diseases—

(a) *Host-plants*.—The host-plants on which the white-fly, *Bemisia tabaci*, vector of tobacco leaf-curl virus was observed feeding and breeding were potato, bhindi, tobacco chilli, cluster bean, *Solanum nigrum*, tomato, etc.

The breeding of the white-fly on tobacco in the rearing cages was maximum during the middle of October followed by a decline about the middle of January and again an increase in February.

(b) *Survey of sucking type of insects*.—Among the sucking insects observed on potato crop the more important species were *Myzus persicae*, *Empoasca devastans*, *Calocoris angustatus*, *Aphis gossypii*, *Agrotis ypsilon*, *Phyllotreta cruciferae*, *Bemisia tabaci*, etc.

5. *Termites and their control*.—Experiments on the control of termite attack on sugarcane crop by means of DDT, 666 were repeated. The data obtained were statistically analysed and the results are as follows:—Dipping of setts in 5% DDT emulsion or in a mixed solution of 2% paris green and 4% lime in water or setts grown in soil treated with 1.25% DDT emulsion at 320 galls. per acre were significantly better at 1% level than the control, while setts treated with 1% lead arsenate mixed with 10% lime in water, or soil treated with 0.5% gammexane at 20 lbs. per acre were superior to the control at 5% level. On the other hand setts treated with 0.5% gammexane have shown no significant difference over the control. It may thus be concluded that the setts treated with paris green and lime or soil treated with 1.25% DDT emulsion were superior to those treated with 0.5% gammexane.

6. *Insecticides and fumigants*.—In the previous year work on the insecticidal properties of opium and tobacco was carried out against general crop pests and stored grain pests to study their contact and insecticidal action. Further work was carried out this year with these and a new insecticide, extracted from the plant *Adhatoda vasica* to study their effect as stomach poison and smoke.

(i) *Effect of opium marc as stomach poison*.—In these experiments marc and its various common alkaloid byproducts were tested in two ways:—One method was by coating of the substances dissolved or suspended in acetone to the flower perals of cowpea, tori, etc., so that on evaporation a thin layer of the poison may remain, and another method was by smearing lanolin on the

petals and dusting the poison on it and covering it with other petals without poison. The petals thus poisoned were fed to the beetles of *Mylabris pustulata* after starving them for 1-2 days. Pure narcotine and narcotine acetate produced a fair amount of toxicity. A dosage of about .01 gm. per insect was found to be sufficient to cause a serious moribund condition, while opium marc and two compounds each of morphine and codeine, i.e., morphine hydrochloride and morphine sulphate and codeine hydrochloride and codeine oxalate were ineffective.

Some organic acids and essential oils like citric acid, butyric acid, oleic acid, clove oil and olive oil were also tested to ascertain their properties as attractants in combination with marc preparations. Out of these only oleic acid showed a little response, while citric acid and clove oil showed a repellent action on the contrary.

- (ii) *Effect of marc as smoke.*—(a) Against houseflies and some common crop pests:—Preliminary experiments were carried out with marc as smoke against houseflies and pests of brassica, *Rhopalosiphum pseudobrassicæ* (aphid) and *Bagrada picta* (painted bug) at room temperatures 62°-65° F. with varying durations of exposure. Marc powder was burnt in a vessel having two outlets one of which was connected with a partial vacuum insect container and the other was connected with the air inlet tube. The powder was introduced through a top opening which could be closed at will. Smoke was produced within by heating below. Cent per cent kill of flies was obtained by exposure for 5-15 minutes, whereas in the case of the two species mentioned above there was negligible mortality even with 15 minutes exposure.

Smokes of five compounds of codeine and morphine were also tested. The results obtained in all these were almost similar to those described above.

(b) Against mosquitoes:—An exposure of 2-3 minutes to a dense smoke of marc caused up to a maximum mortality of cent per cent of mosquitoes unlike a light smoke which caused only 30-50% mortality.

- (iii) *Adhatoda vasica extract.*—Four preparations of adhatoda received from the Chemistry Division were tested against the larvæ of *Corcyra cephalonica*, *R. pseudobrassicæ* and *B. picta* and found ineffective except in the case of second and third instar nymphs of the last named species where the mortality was only 20-30%.

- (iv) *Nicotine dust.*—Dust obtained from dry tobacco stems when mixed with hydrated lime in the ratio of 1 : 1 was found to have more lethal effect than 2% DDT in chalk against *Macrosiphum solidaginis*. Further the dust was more effective than spray prepared by mixing 1 part of tobacco stems in 50 parts of water.

7. *Control of houseflies and mosquitoes.*—(a) Control operations against houseflies were continued. The major breeding places of flies were cattle dung pits in the Divisions of Agronomy and Botany of the Institute. The pits were covered with a 4"-6" layer of packed earth which caused suffocation followed by death of numerous maggots.

Adult flies were observed immigrating towards the Institute area from the adjoining villages where sanitary conditions were far from being satisfactory owing to the influx of human population. These were captured by setting up a series of traps using decomposed mustard oil cake as bait. In winter months of December-February due to low temperature conditions and proper disposal of the manure, the fly population remained very low.

(b) Anti-mosquito campaign was continued throughout the period under report. During the period July-September and March, the breeding had increased due to water accumulations in the monsoon season. As a result of survey carried out in and around the Institute, extensive breeding was observed near the tent factory on the Pusa Road, and the area was treated with malariol with the help of the New Delhi Municipality staff. The residences on the Institute area were sprayed with pyrethrum-kerosine and this resulted in the destruction of a large proportion of the adult mosquito population.

8. *Insect pests of potatoes*.—Among the injurious insects observed, the more important species were *Empoasca devastans*, *Plusia orichalcea*, *Scymnus* sp., *Dolychoris indicus*, *Piezodorus rubrofasciatus*, *Eusarcocoris ventralis*, *Cirphis unipuncta*, *Myzus persicae*, etc.

9. *Observations on Indian insects of economic importance*.—Over 73 crop plants and wild plants were examined for insect damage during the period under report. Of the numerous insects found, the following were present in a pest form:—*Engytatus tenuis*, *Nysius inconspicuus*, *Myzus persicae* and *Pulsia orichalcea* on tobacco; *Srcipophaga nivella* on sugarcane; *Marasmia trapezalis* and *Chilo zonellus* on maize; *Aphis maidis* on wheat; *Plusia orichalcea*, *P. nigrisigna*, *Heliothis armigera*, *Laphygma exigua* and *Aphis laburni* on gram; *Utetheisa pulchella* on sunn-hemp and *Heliotropium* sp.; *Agromyza obtusa* on arhar, *Piezodorus rubrofasciatus* on lucerne; *Myllocerus lativirens* on apple; *Phyllotreta cruciferae*, *Rhopalosiphum pseudobrassicae* and *Bagrada picta* on brassicas; *Acanthiophilus helianthi*, *Macrosiphum solidaginis* on safflower; *Athalia proxima* on brassicas; *Antigastra catalaunalis* on *Sesamum* and *Amsacta moorei* on sunn-hemp.

10. *Immature stages of Indian insects*.—Studies on the immature stages of Indian insects were continued. The biology of *Harpactor* sp. was studied in detail. Immature stages of the following species were reared in the Insectary:—*Acanthiophilus helianthi* on safflower; *Athalia proxima* and *Plutella maculipennis* on cabbage; *Plusia orichalcea* on tobacco; *Heliothis armigera* and *Agrotis* sp. on gram; *Euproctis lunata* on castor; *Leucinodes orbonalis* on brinjal; *Sylepta derogata* on cotton; *Agromyza obtusa* on arhar and *Hypera medicaginis* on lucerne.

11. *Predators and Parasites*.—The following were the predators recorded on various hosts:—*Chilomenes sexmaculata* and *Coccinella septempunctata* on brassica aphids, *Rhopalosiphum pseudobrassicae*; *Harpactor costalis*, *Coranus spiniscutis* and *Chrysopa* sp. on *Myzus persicae*; *H. costalis*, *H. marginellus* and *Coranus* sp. on nymphs of *N. inconspicuus*; *Brumus suturalis* and *Laius* sp. on pea aphids, etc. Among the parasites observed the more important ones were *Microbracon* sp. on *Plutella maculipennis* and braconids on *Plusia* sp., *Laphygma exigua* and *Heliothis armigera*.

Hitherto undescribed morphological structures of *Epipyrops melanoleuca* Flet. (Fam: Epipyropidae) ecto-parasite on *Pyrilla* spp. were studied.

12. *Taxonomic studies of insect groups of economic importance—*

- (a) *Parasitic Hymenoptera*.—Studies on the systematics of this group were continued.
- (b) *Isoptera*.—Work on the taxonomy of this group which was taken up by the newly introduced school of research was continued by the main Division.
- (c) *Other groups*.—Studies on the Indian Acrididæ were continued.
- (d) Parasitic Hymenoptera collected from Baluchistan was studied and a new species described.

13. *Balloon Insect-Trap*.—A special apparatus known as the balloon insect-trap has been devised for the first time in India whereby sampling of insect fauna inhabiting the upper air at different altitudes can be carried out. Extensive sampling tests if carried out throughout the year in different localities, very valuable data are likely to yield regarding the aerial fauna in relation to the meteorological conditions of the different altitudes and to elucidate whether any of the species collected would fall within the group of destructive insect pests against which quarantine measures shall have to be considered.

14. *National Pusa Insect Collection*.—The staff of the Division were engaged for about two months in partitioning the named collection of insects of all orders, and about 18,496 specimens comprising 5,917 species were set apart in cabinets for the Pakistan Government. During the period, the following specimens were received as donations and incorporated into the collection:—86 specimens of Apidæ (of which 46 arrived in good condition) from Mirostav Kocurek of Hranice, 47 species of Coccinellidæ, 3 of Mardellidæ, 15 of Anobiidæ and 2 of Apidæ from Ing. Viktor Gunther, Praha XII, Czechoslovakia. In all 90 specimens of *Sitophilus oryzae* were donated to the Professor of Entomology, University of California. The store boxes containing the collection were disinfected by means of petrol-naphthalene mixture for preservation.

III.—ADVISORY

Among advisory work mention may be made of the following:—

- (i) Control measures against *Laphygma exigua*, a pest of cotton were suggested to Superintendent, Government Experimental Farm, Beawar-Ajmer-Merwara.
- (ii) Sixty potted plants of the Horticultural Department, New Delhi, were examined in the Mycology Division for insect pests; and as some plants were found to have few immature stages, all of them were sprayed with fish oil rosin soap and made free from living insects and a certificate to that effect was issued.
- (iii) The milk shed of the Dairy was disinfected against flies by spraying DDT in kerosine.
- (iv) Thirteen pounds of seeds of Indian grasses legumes received from Indian Council of Agricultural Research and meant for transport overseas were examined and fumigated.

- (v) 120 coloured plates of various crop pests and beneficial insects were supplied to the Principal, Central College of Agriculture, New Delhi; 75 coloured plates to Mrs. B. E. Crowther, Wed Medani, Anglo-Egyptian Sudan and 68 to Honorary Secretary, Taluk Development Association, Anand (Bombay Province).
- (vi) Detailed information regarding the habits, life-history and control of the stored grain pest, *Trogoderma khapra*, reported to be damaging stored coconut cakes in the Tata Oil Mills, Tatapuram (South India) was furnished to the Manager of the Mills.
- (vii) Information regarding coloured plates of insect pests and books on the subject of Entomology and literature on birds was supplied to Honorary Secretary, Taluk Development Association, Anand (Bombay Province).
- (viii) Information regarding 49 insect hosts of Braconid parasites (*Apanteles* sp.) was supplied to Dr. M. S. Mani, Prof. of Zoology, St. John's College, Agra.
- (ix) Brassica seedlings were sprayed in the Botanical Division against *Athalia proxima* and *Phyllotreta* sp. with lead arsenate solution (1 lb. in 50 gallons of water) with encouraging results.
- (x) The seed storage godowns at Karnal and potato storage godowns at Pusa were disinfected by means of 5% solution of DDT in kerosine against storage pests. Dairy buildings in Karnal were similarly fumigated. Nine hundred potato cultures were fumigated at Pusa with carbon bisulphide against potato tuber moth.
- (xi) The following specimens received from various correspondents were identified:—
 - (a) Three species of storage pests of paddy from Entomological Assistant, Gauhati.
 - (b) *Chilo zonellus*, stem borer of maize and larvæ of *Argyria tumidicostalis* boring sugarcane for Sugarcane Specialist.
 - (c) *Coptotermes travians* (Havil) for Plant Protection Adviser to Government of India.
 - (d) Beetles of *Phyllotreta* sp. damaging brassica seedlings for the Head of the Division of Botany.
 - (e) Moths of *Corcyra cephalonica*, a storage pest of jowar and a species of Coleoptera for the Entomologist, Gwalior State.
 - (f) *Empoasca devastans* Dist., *Typhlocyba*, sp. and *Eugncathodus* sp. for Head of the Division of Mycology.
 - (g) Nine species of Isoptera for Prof. K. N. Bahl, Lucknow University.

- (h) Four species of insects for Head of Zoology Department, Allahabad.
 - (i) *Phyllotreta cruciferae* Gæze, a pest radish for the Directorate of Plant Protection and quarantines.
 - (j) Three species of fruit flies for the University of Allahabad.
 - (k) Four species of Bruchids for the Principal, Agricultural College, Bapatla (South India).
 - (l) Seven species of different families for the Entomologist to Government of Bombay, Poona.
- (xii) Sixty-three species of Chalcididæ were supplied to Dr. R. Menon for taxonomical studies and eight specimens of moths to Mr. A. P. Kapur, Commonwealth Institute of Entomology, British Museum, London.
- Eight specimens of Chalcids and a large number of Cecidomyids were sent to the Director, Commonwealth Institute of Entomology, British Museum, London, for identification.
- (xiii) A list of literature references on the potato tuber-moth and a coloured plate illustrating the different stages of the pest were furnished to the Manager, Geigy Insecticides, Ltd., Bombay.
 - (xiv) Information regarding the distribution of *Pycnoscelus surinamensis* L. was furnished to Dr. Seshachar, Bangalore.
 - (xv) Information regarding the occurrence of *Schistocerca gregaria* in Kumaun was supplied to Dr. Roonwal, Zoological Survey of India, Benares Cantt.
 - (xvi) Information regarding life-histories and control measures of pests of rice in India was forwarded to Director, I. A. R. I., for transference to Mr. K. Ramiah, Food and Agricultural Organization, United Nations, Bangkok, Siam.
 - (xvii) A complete report on the entomological investigations carried out at Pusa (Bihar) on the tobacco leaf-curl disease during 1936-41 was forwarded to the Head of the Division of Botany for incorporation in the final report of the Tobacco Research Sub-station, Guntur.
 - (xix) Information regarding literature and biology of *Coccotrypes dactyliperda*, a beetle pest of nuts was supplied to Government Entomologist, Coimbatore.
 - (xx) A list of books and journals for the library was furnished to the Director, Central Tobacco Research Institute, Rajamundry (Madras Presidency).
 - (xxi) A note on the queries raised in the Constituent Assembly regarding the study and control of pests of coffee was forwarded to the Director, I. A. R. I.

- (xxii) The following seed samples meant to be sent outside India were examined and fumigated and necessary certificates of freedom from insect pests were issued thereon:—12 samples of sesamum seeds received from the Head of Division of Botany meant for Dr. D. G. Langham, Maracay (Venezuela); 21 samples of N. P. Wheats meant for Director, Research Association of British Flour Millers, London; 2 samples of *Brassica* spp. meant for U. S. A.; 5 samples of *Plantago* for Arizona; 9 samples of gram and pigeon pea meant for Victoria State Research Farm, Werribee; 10 samples of brassica, *Sesamum* and linseed meant for California and different samples of wheat, barley and oats for U. S., China and Phillipines; 21 samples of seed varieties meant for supply to Prof. V. J. Chapman, Prof. of Botany, Auckland University College, Auckland, New Zealand; 11 varieties of *Solanum* meant for Cambridge; 12 ears of wheat N. P. 165 meant for Director, Department of Scientific and Industrial Research, Slough Bucks; 7 samples of leguminous seeds to be sent abroad; 4 packets of barley for Phillipines; 10 samples of wheat for Burma and 3 samples of wheat for Brazil.

IV.—TRAINING OF STUDENTS

The training of the post-graduate students was continued. Seven students who were admitted to the first year post-graduate course were given 170 hours of lectures, 695 hours of field work and laboratory practical work. Three students of second year course who were given research problems had continued to work.

V.—TRAINING OF RESEARCH FELLOWS

Four Research Fellows appointed by the Indian Council of Agricultural Research were admitted to work in this Division on the Taxonomy of Agromyzidæ, Tachinidæ and Trypetidæ of (Diptera of economic importance), Aphididæ, Ichneumonidæ and Isoptera (Termites). Two Fellows working on the last two families opted for Pakistan and finally left the Division. One Research Fellow was appointed this year by the I. C. A. R. to continue the work on Taxonomy of Ichneumonidæ while the post of the Research Fellow for Termites has been abolished by the I. C. A. R. A new Research Fellow has been appointed to work on the Taxonomy of phytophagous Chalcidoidea under the auspices of the Institute.

VI.—DIVISIONAL MEETINGS

Six monthly meetings of the members of the Entomology Division were held during the year when observations on important pests of crops during each month were reviewed. Six research papers were read and discussed.

VII.—PROGRAMME OF WORK (1948-49)

- I. *Insect Population Studies*.—(i) Development and standardization of technique and population study, (ii) study of fluctuation of populations of spotted boll-worms in relation to biotic and climatic factors will be continued.

- II. *Insect Toxicology*.—(a) Establishment of Insecticidal Testing laboratory: (i) Standardization of Bioassay techniques. (ii) Standardization of Microdeterminatam techniques. (b) Establishment of mass rearing insectary for test insects.
- III. *Biological Control of Pests of Sugarcane*.—(i) Field survey of sugarcane pests and natural enemies. (ii) Mass breeding and biology of *Trichogramma evanescens minutum*, *Bracon* (*Microbracon*) *gelechiae*, *Stenobracon deesæ* and *Telenomus beneficiens*. (iii) Field experiments on the biological control of sugarcane pests (as per programme approved by the Indian Central Sugarcane Committee). (iv) Experiments in storage godowns to control potato tuber moth by liberation of the exotic braconid parasite, *Microbracon gelechiae*.
- IV. *Pests of stored foodstuffs*.—(i) Pests of jowar and pests of pulses. (ii) Pests of dry fruits.
- V. *Discovery and control of insect vectors of the virus diseases of Indian crops*.—(i) Survey of the white-fly and other insect vectors of virus diseases of economic crops like potato, papaya, castor, etc. (ii) Field-scale trials on the control of tobacco leaf-curl disease in co-operation with some Provincial Entomologists and the Central Tobacco Research Committee.
- VI. *Sampling of the upper air insect fauna*.—A special apparatus known as the "Balloon Insect-Trap" has been devised for the first time to carry out sampling tests of the insect fauna at different altitudes. The apparatus is under construction and will be put to use when ready for collection of insect fauna.
- VII. *Termites and their control*.—Systematic and biological studies and control work of termites common in Delhi and Karnal.
- VIII. *Insecticides and Fumigants*.—Trials of important insecticides like DDT and 666, fumigants and work on insecticides made from indigenous plants and materials like tobacco and waste products in opium manufacture.
- IX. *Control of House-flies*.—Field-scale trials of various methods.
- X. *Insect Pests of Potato*.—Special attention will be paid to the sucking type of insect fauna and potato tuber moth.
- XI. *General observations on insects of economic importance*.—Records of degree of incidence and damage of important pests of crops in the field; and vigilant watch of insects assuming or likely to assume pest status.
- XII. *Immature stages of Indian insects*.—Studies of immature stages of Indian insects and their mode of damaging crops.
- XIII. *Predators and parasites*.—General biology of promising predators and parasites of insect pests will be continued.

- XIV. *Standardisation of technique for fumigation of imported fruits.*
- XV. Investigations on the effect of different intensities of light on the reproductive power of sucking insects and on the degree of susceptibility or resistance of different varieties of tobacco to their attack.
- XVI. *Taxonomic studies of insect groups of economic importance.*—Studies on Indian Parasitic Hymenoptera, particularly Ichneumonidæ, Diptera of Agricultural importance (Agromyzidæ, Trypetidæ and Tachinidæ) and Rhynchota particularly Aphididæ and Isoptera will be continued.
- XVII. *National Pusa Insect Collection.*—Building and maintenance of a reference collection of insects of India.
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Report of the Head of the Division of Mycology and Plant Pathology

I.—INTRODUCTORY

In spite of the shortage of staff during the year under report, the progress in relation to the programme laid down for research and postgraduate training was satisfactorily maintained. During the year under report Mr. J. F. Dastur, Head of the Division of Mycology, retired from service and the post remained unfilled till 22nd June 1948. Dr. R. S. Vasudeva, Virologist, held charge of the Division in addition to his own duties till 22nd June 1948 when he was appointed as Head of the Division. Dr. B. Chena, Assistant Systematic Mycologist, was relieved from this Division on 31st March 1948 to take up his new appointment as Government Mycologist in Bihar. Mr. S. P. Raychaudhuri, Assistant Plant Pathologist, was appointed to the post of Assistant Virologist with effect from 1st August 1947. Dr. M. I. Gattani and Dr. M. K. Hingorani were appointed as Assistant Plant Pathologist and Assistant Systematic Mycologist with effect from 22nd September 1947 and 1st April 1948 respectively.

The three Schemes, *i.e.*, Seed Potato Certification Scheme, Seed Potato Multiplication Scheme, financed by the Indian Council of Agricultural Research and Scheme for Research on Diseases of Sugarcane financed by the Central Sugarcane Committee, were in operation during the year under report. The work of these Schemes was responsible for increased strain on the staff of the Division due to depletion of staff of these Schemes. In fact, the Seed Potato Multiplication Scheme was run without any staff provided under the Scheme and the strength of the staff of the Certification Scheme was less than half the sanctioned staff during the major part of the year.

In addition to the increased number of postgraduate students, two Research Fellows, three Honorary Research workers and two short-course students were admitted.

II.—RESEARCH

Section of Plant Pathology.

1. WHEAT (*Triticum vulgare* L).

(a) *Loose Smut* : (*Ustilago tritici* (Pers.) Rostrup).—Seventy-eight varieties of wheat supplied last season by the Division of Botany and infected with two isolates L₁ and L₂

with a view to test their resistance to the smut, were planted during the year under report and the following results were obtained. With isolate L_1 forty-seven varieties did not take infection, 9 varieties showed an infection up to 10 per cent. and 22 above 10 per cent. With isolate L_2 fifty-one varieties did not take infection, eight varieties showed infection up to 10 per cent. and 19 above 10 per cent. Varieties I.P. 748, W. 7-F. 9 P. 13, W. 9-F. 9 P. 14, M. M. 10, Simla 2, 5, 6, 8, 9, 12, 20, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 32, 35, 36, 37, 38, 39, 41, 42, 44, 46, 47, 49, 52, 53, 56, 57, 59, 61, 62, 63, 64 and 66 did not take infection either with L_1 or L_2 . Fifteen varieties I. P. 755, 756, 760, 761, 762, 764, 766, 773, W. 10-F. 9 P. 14, N.P. 12-2, N.P. 54, O.C. 10, P.C. 35, M.M. 43 and Jaipur 10 showed more than 10 per cent. infection and may therefore be regarded as susceptible. Jaipur 10 appeared to be the most susceptible variety as it showed an infection of more than 70 per cent. Varieties Punjab 8A, C. 518 and C. 591 were infected to serve as controls and they showed infection percentage of 65.8, 73.3, 12.5 and 27.3, 20.9, 12.6 with L_1 and L_2 respectively. The remaining 23 varieties did not show appreciable differences in percentage of infection with L_1 and L_2 . One hundred and twenty-six new varieties supplied by the Botanical Division for tests against resistance to the smut have been inoculated with a mixture of isolates L_1 and L_2 as well as with isolate L_1 separately. Forty-one varieties of wheat inoculated last year at Hoshangabad for the Wheat Breeder, C. P. to test their resistance to local collection of loose smut and planted this year showed that 22 varieties did not take infection. The results of 19 varieties were not made available. During the year under report 40 C. P. varieties were inoculated with a local collection to test their resistance to the disease.

Physiologic Races.—The preliminary tests carried out with a view to study the physiologic races indicated as if all the eight isolates L_1 to L_8 belong to one race. Dr. Hanna, however, was of the opinion that at least three physiologic races were represented in the six collections out of the 8 supplied to him. In the tests conducted at Delhi a set of 24 differentials, mostly belonging to *Triticum vulgare* group, were used but during the year under report a set of 15 new differentials consisting of six different groups of wheat were used for the analyses of different collections.

(b) *Karnal Bunt*: (*Neovossia indica* (Mitra) Mundkur).—Inoculation experiments with cultures were not repeated as the old cultures had consistently given negative results during the last two years. Since viable spores of the fungus were not available at the proper time, infection tests on the plants of three susceptible varieties raised for this purpose could not be made. Wheat varieties I.P. 4, I.P. 165, C. 228, C. 591 and N.W.R. 28 were, however, found naturally infected late in the season both at Delhi and Karnal. The inoculation tests with fresh material were conducted on plants of 2 varieties, *i.e.*, Agra Local and I.P. 125 at Simla in May 1948. Germination tests of the fresh material collected are now being conducted.

(c) *Black Rust*: (*Puccinia graminis* Pers.).—An experiment was laid out to determine the effect of black rust on yield of wheat. Wheat varieties Agra local and I.P. 4 were sown in plots 15 ft. $\times$ 12 ft. each. Four hundred seeds were sown in each plot and ten such plots were put under each variety. Five plots of each variety were inoculated with black rust at heading stage and the other five were kept rust-free to serve as checks by frequent application of sulphur dust. The data regarding the effect of black

rust on yield, grain weight and protein content in the two varieties under test are summarized below:—

Variety	Treatment	Infection *	Yield in 900 sq. ft. (lb.)	Average yield per acre. (lb.)	% reduc- tion in yield	Average Wt. per 1000 grains (gm.)	Average reduc- tion in yield per 1000 grains (%)	Crude protein per cent
Agra—(†)								
Local	Control	Trace	36	1682.4		37.7		9.69
Wheat	Rusted	90%	19	919.6	55.6	19.1	49.5	14.39
I.P. 4	Control	Trace	75	3630.0		43.7		12.36
	Rusted	90%	46	2226.4	38.7	28.5	34.8	12.22

(d) *Performance of Seed from rust-affected Wheat Plants.*—In 1947 the outbreak of wheat rust epidemic resulted in considerable destruction of crop. It was doubtful whether the produce of grain from the affected areas would even meet the needs of seed requirements of those particular areas and the question arose as to the extent shrivelled grain obtained from rust-affected plants could be used for sowing purposes. In this connection 187 samples of seed obtained from affected localities were tested for germination and 139 samples were recommended as suitable for seed purposes as they showed germination per cent. of above 70. Most of the remaining samples showed germination per cent. of 40 to 65. Only three samples showed as low germination as 12-14 per cent. To determine whether crop raised from such seed would be profitable, experiments were also conducted with three varieties, N.W.R. 28, I.P. 52 and I.P. 111. The germination per cent. of grains in these varieties is shown by the figures given below:—

						% germination in the laboratory	% germination in the field.
N.W.R. 28	Healthy	...	...	...	...	98	97.5
	Rust-affected	...	...	...	...	90	83.2
I.P. 52	Healthy	...	...	...	...	99	95.7
	Rust-affected	...	...	...	...	79.6	75.7
I.P. 111	Healthy	...	...	...	...	98	98.2
	Rust-affected	...	...	...	...	63	50.0

The growth rates of plants so raised were taken at regular intervals. The plants raised from healthy seeds generally exhibit higher growth rate to begin with but in due course, the plants raised from rust-affected plant grains make up the growth. The difference in tillering of plants raised from healthy and rust-affected plant seed was

†(Agra-Local)—An improved variety of *vulgare* wheat. On account of rain and strong winds there was a considerable amount of lodging in this variety.

I. P. 4. Comparatively early maturing variety.

*Based on the scale adopted by the Division of Cereals Crops & Diseases, Bureau of Plant Industry, United States Department of Agriculture.

also not appreciable excepting in the case of variety I.P. 111 where the plants raised from rust-affected plant grains exhibited better tillering probably owing to smaller number of plants per unit area as a result of poor germination.

There was no difference in the number of ears and weight of grains per plant between the two sets in varieties N.W.R. 28 and I.P. 52, but in I.P. 111 the number of ears as well as weight of grain obtained from plants raised from rust-affected plant seed was greater on account of better tillering mentioned above. The data are given below:—

						Average ears per plant.	Average Weight of grains (Grams) per plant.
N.W.R. 28	Healthy	...	...	...	...	5.3	7.1
	Rust—affected	...	...	...	...	5.4	7.5
I.P. 52	Healthy	...	...	...	...	6.7	8.2
	Rust—affected	...	...	...	...	6.5	8.3
I.P. 111	Healthy	...	...	...	...	5.9	7.7
	Rust—affected	...	...	...	...	9.6	13.8

No appreciable differences were observed in the absolute weight and density of grains.

The yields of grains in the three varieties, *viz.*, N.W.R. 28, I.P. 52 and I.P. 111 were 111.4, 120.7, 111.4, and 92.9, 102.1 and 74.3 grams per square yard for healthy and shrivelled seed respectively. The difference in percentage germination of the 3 varieties in the order stated above was 14, 20 and 48. Obviously, if the number of seed per unit area is increased an yield which favourably compares with the healthy seed crop can be obtained from the crop raised from rust affected plant seed.

2. JOWAR (*Sorghum vulgare* Pers.)

Long smut : (*Tolyposporium ehrenbergii* (Kuhn) Pat.).—All attempts to reproduce the disease artificially by inoculating with the cultures of the fungus have given negative results for the third successive year in spite of the fact that about 400 inoculations were done in this connection.

3. PIGEON-PEA (*Cajanus cajan* Spreng.)

Wilt : (*Fusarium udum* Butler).—The Botany Division supplied 22 varieties for testing their resistance to the wilt disease. The plants for such tests were raised in pots containing unsterilized soil to which was added a heavy dose of pure inoculum of the fungus; also wilted pigeon-pea stalks were used as inoculum. Four varieties, *viz.*, I.P. 41, C. 15, D. 16-17-2 pt. 3 and D. 333-4-22 did not take infection and appeared to be resistant, while varieties N.E. 41-2A and F. 2 pt. 2 showed high degree of susceptibility; the percentage of infection being 80.0 and 85.7 respectively. Highest disease incidence was observed during November-February at Delhi.

As reported last year, the percentage of infection in the sterilized soil was much greater than in the unsterilized soil. The two varieties, *viz.*, I.P. 69 and N.E. (a) used

for confirmation of these tests during the year under report showed infection per cent. of 40 and 30 in unsterilized soil while in sterilized soil the mortality was as high as 60 and 70 per cent. respectively. The following micro-organisms were isolated from the unsterilized soil in which the plants had been raised:

Rhizopus nigricans, *Aspergillus niger*, *A. glaucus*, *A. sulphureus*, *Acrothecium* sp., *Rhizoctonia bataticola*, *Cunninghamella bertholletiae*, *Mucor* sp., *Fusarium udum*, *Actinomyces* sp. and 6 isolates of bacteria differentiated on the basis of colony characters. The percentage of straw colonized by the predominant forms in the micro-organisms are given below:

Fusarium udum 25%, *Aspergillus glaucus* 35%, *A. sulphureus* 25%, *A. nigricans* 25%, Bacteria 15% to 20%, *Rhizoctonia bataticola* 15%, *Rhizopus nigricans* 10%, *Mucor* sp. 10%. *Aspergillus* spp. were predominant till November, but from December onwards *Rhizopus nigricans* and *Cunninghamella bertholletiae* were more frequently obtained.

The hydrogen-ion concentration of the soil during the course of these experiments was frequently tested and found to be 8.2.

Antibiosis.—All the fungi isolated from unsterilized soil gave negative results when tested for antagonistic action against *Fusarium udum*, the wilt organism, over a wide range of hydrogen-ion concentrations. Two isolates of bacteria, however, exhibited marked antibiotic action on the wilt organism at a pH range 6 to 8.8. The optimum antagonistic effect was observed at pH 8.6. The inhibitory effect was also observed in the filtrates of bacterial cultures even after passage through L₃ Chamberland candles. Four-day old filtrate inhibited the growth of *Fusarium udum* and several other fungi, e.g., *F. vasinfectum*, *F. oxysporum* and *Alternaria solani*. The active principle in the bacteria-free filtrate appears to be fungistatic and is thermostable.

4. GRAM (*Cicer arietinum* L.)

(a) **Wilt:** (*Fusarium orthoceras* App. et Wr.).—During the course of investigation on the wilt disease it was observed that rootlets of apparently healthy gram plants were invaded by mycorrhizal fungi, *Fusarium* sp., *Rhizoctonia bataticola* and a species of *Pythium*. Attempts to infect healthy plants with the organisms isolated were unsuccessful. Similarly, the organisms isolated from healthy and diseased nodules of the plants failed to bring about infection. The organisms isolated from plants showing different symptoms are given below:—

Symptoms.	Organisms isolated.
Bronzing of leaves	<i>Fusarium</i> species, <i>Operculella Padwickii</i> .
Yellowing of the upper leaves	Nil.
Wilting	<i>Fusarium</i> sp., <i>Operculella Padwickii</i> .
Yellowing of leaves followed by shedding of leaflets from bottom upwards.	<i>Rhizoctonia bataticola</i> .
Rotting of upper portion of stem	<i>Sclerotinia sclerotiorum</i> .

It has been confirmed by artificial inoculations that *Fusarium orthoceras* is responsible for at least one wilt disease of gram. Inoculations with *Operculella Padwickii* bring about yellowing and folding of the leaflets upwards and result in drying up of the whole plant.

(b) **Rust:** (*Uromyces ciceris-arietini* (Grogg.) Jacz.).—This rust appears rather late in the growing season both in Indo-Gangetic plains and Bihar. Only the uredial and

telial stages have been observed, the latter being very rare. The uredospores germinate readily between 5°-30° C. with optimum at 12°-18° C. The uredospores were found to be viable for 48 weeks when stored at a temperature of 5°-7° C., whereas the viability at 35° C. was only 8 days. The uredospores were killed after 96 and 72 hours when stored at temperatures of 40° and 45° C. respectively. The incubation period of the rust at 11°-12°, 17°, 20°-25° and 25°-30° C. was 15, 13, 11 and 9 days respectively.

The teleutospores appear when the crop is ready for harvest in the end of April. Their formation could be induced by increasing the amount of carbohydrate in detached leaf cultures. *Trigonella polycerata*, a leguminous weed, was found infected by the rust in February. This weed is widely distributed in the hills up to an elevation of 6,000 ft.

5. SUGARCANE (*Saccharum officinarum* L.)

(a) *Red-rot*: (*Collectotrichum falcatum* Went.)—During the year under report 97 cane varieties supplied by the Government Sugarcane Expert were tested for their resistance to red-rot by inoculating with the plug method. Altogether 4,700 growing canes were inoculated with a highly virulent isolate No. 244 of the fungus. Of all the varieties tested, 7 appeared to be highly resistant (S.S. Burma, S.S. Glagah, Co. 214, Katha, Sclerostachya and S.S. Coimbatore) whereas 56 reacted as moderately susceptible and the remaining 31 were found to be susceptible. No observations could be made on 3 varieties.

The resistance tests were also conducted by nodal infection method with 89 varieties out of 97 used in the previous experiment. In this connection about 4,500 canes were infected with the same isolate of *Collectotrichum falcatum*. Varieties Co. 14, Katha, Sclerostachya and S.S. Burma showed high degree of resistance when tested by this method also. Varieties Co. 213 and Co. 299 proved to be highly susceptible in both cases.

Nineteen isolates of *C. falcatum* were tested on a set of 10 differential cane varieties with a view to study the physiologic races of the red-rot organism. The isolates tested can be grouped into 5 classes depending on their virulence. Isolate 244 proved to be the most virulent, as 7 differential varieties showed a high degree of susceptibility. The remaining 3 differentials were moderately susceptible. Isolate 278 was next in order of virulence as 3 differential varieties gave susceptible reaction. Isolates 3 and 126 gave susceptible reaction on only one variety. Isolates 83, 205, 226, 233, 259, and 271 gave moderately susceptible type of reaction on all the 10 differentials. The remaining 9 isolates did not show susceptible reaction on any of the differentials and could, therefore, be grouped together for practical purposes. The 2 virulent isolates No. 244 and 278 are light coloured and highly sporing.

(b) *Smut*: (*Ustilago scitaminea* Syd.)—Ninety-three cane varieties tested for their resistance to red-rot were also tested for their resistance to sugarcane smut at Karnal by infesting the setts with viable smut spores at planting time. Twenty-nine varieties showed less than 15% infection and may be regarded as resistant and eighteen varieties showed infection of 15-30% and may be regarded as moderately susceptible. The remaining 46 varieties showed infection above 30% and may therefore be taken as susceptible. Some of the cane varieties such as "Katha", "Saretha", "Chunnee", Co. 313 showed infection of 70-100%. Cane varieties Co. 356, 617, 630, Uba, S.S. Burmah, S.S. Glagah, Java and Sclerostachya showed a high degree of resistance.

Varietal resistance tests with 40 cane varieties were also conducted at Delhi. Of these, 10 varieties showed less than 15% infection, four 15-30% infection and the

remaining twenty-six 30-60 per cent. infection. Varieties Co. 612, 615, 617, 618, 631, 641, 643, 632, 636 and 644 were found to be resistant, and varieties listed below were found to be highly susceptible: Co. 465, 623, 624, 627, 630, 635. Co. K. 35. Co. K. 37 and Co. L. 4.

Loss due to Smut.—Observations were recorded on previous year's ratoon crop of Co. 312 with a view to assess the losses due to smut. It was observed that the average weight of millable canes per smutted clump was 1.63 lb. as against 2.64 lbs. for healthy clump. The average weight of millable cane per clump in the control plot was 2.25 lb.

6. POTATO (*Solanum tuberosum* L.).

One hundred and two hybrids and cultures of potatoes were tested for their resistance to Late Blight (*Phytophthora infestans* (Mont.) de Bary) at the Potato Breeding Substation, Simla, during the year under report. Sixty-eight hybrids and cultures have been found to be susceptible while 34 are resistant to the disease.

The potato crop at Hapur and Meerut was found infected both by Late Blight and Early Blight (*Alternaria solani* (E. & M.) Jones & Groat) during the month of February. *Gola* and *Phulwa* varieties which are commonly grown in this area were found infected by Late Blight. This is the first record of Late Blight disease occurring on *Phulwa* variety, seed of which is always kept in the plains. It was obviously a case of secondary infection from the *Gola* crop, seed of which is obtained from the hills.

7. LINSEED (*Linum usitatissimum* L.).

Rust: (Melampsora lini (Pers.) Lev.).—One hundred and twenty-four varieties of linseed, flax and their crosses were tested for seedling and adult resistance against a mixture of four Indian physiologic races of the rust obtained from the Rust Research Laboratory, Simla. Seventy-four varieties listed below proved resistant as a result of inoculation both in the seedling and adult stages.

R.R. 39, 44, 45, 62, 63, 64, 65, 66, 76, 78, 80, 82-Ub., 96, 99, 122, 138, 187, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 207, 208, 209, 218, 226, 229, 236, 239, 240, 242, 247, 248, 249, 250, 252, 257, 260, 261, 262, 267, 271, 272, 273, 279 Ub., 279 B, 279 K-1, 291, 292, 293, 302, 303, 318, 319, 326, 328, A. 1-2, A. 1-3, A. 2-1, A. 17-1-1, Flax Tall, Flax x. N.P. 124 No. 9, Flax x. N.P. 124 No. 6.

Fourteen varieties were semi-resistant as seedlings but resistant or immune in the adult stage, 3 were semi-resistant at both the stages, 3 were susceptible as seedlings but semi-resistant in the adult stage, 29 were susceptible at both the stages while one gave mixed reaction.

8. SAFFLOWER (*Carthamus tinctorius* L.).

Rust: (Puccinia carthami (Hutz.) Corda).—This rust has been found to attack both the cultivated species *C. tinctorius* and wild species *C. oxyacantha*. Experiments were conducted to study the life history, influence of climatic factors on different spore forms and the mode of annual recurrence of this rust. This rust is very common in Peninsular India and was observed in the Experimental area of this Institute during February-March. Uredospores and teleutospores are sometimes preceded by pycnia. It appears that two types of teleutospores are formed: one that germinates soon after

formation and the other that requires a resting period. The teleutospores germinate only between 12°-18° C. They remain viable for about a year when exposed to natural weather conditions in Delhi, but if stored at lower temperatures they remain viable for much longer period. The germination of uredospores was observed to be optimum at about 18° C. The germination was poor at 30°-35° C. and at temperatures higher than that the uredospores lost their viability. A culture of this rust could be maintained only during November-April in Delhi, since the cultures lost their viability during May owing to high temperature. Inoculation experiments with germinating teleutospores resulted in the formation of pycnia after 10 days and primary uredia 3 days later which shows that it is a brachy-form rust. It has been shown that over-summering teleutospores remain viable and bring about fresh infections the following season. They may come from plant debris lying in the soil or they may be carried with the seed in the form of small bits of infective tissue. Teleutospores from wild safflower may also infect the cultivated species directly or by attacking wild species first. In nature the rust has been observed earlier on the wild species. In a preliminary experiment 44 varieties of safflower were tested but all were found to be susceptible to the rust. Also inoculation tests with single spore cultures have not so far given any indication of physiologic races. Further work in this connection is however, necessary.

9. LENTIL (*Lens esculenta* L.).

Rust: (*Uromyces fabæ* (Pers.) de Bary).—It has been observed that formation of æcia or uredia is governed by the prevailing temperature. In detached leaf cultures secondary æcia were produced at 17°-22° C. whereas uredia were formed at 25° C. This probably explains the development of uredia late in the season. It has also been observed that æcia and uredia perish during the summer that follows the harvest but the teleutospores which stand the heat, germinate during January when the weather is favourable and cause fresh rust outbreaks.

10. MISCELLANEOUS.

(i) *Study of Mixed Cultures*.—The staling substances produced by *Trichoderma lignorum* and *Penicillium notatum* adversely affect the germination of spores of *Alternaria* sp. and *P. notatum*. The staling products are not thermostable but it is indicated that the germination is partially restored by the passage of the liquid through Chamberland candles. It is also indicated that the inhibitory principle is secreted by the fungal mycelium into the medium and is not internal to the mycelium. Further work is required in this connection.

(ii) *Study of air-borne fungal spores*.—The study of airborne fungal spores was continued on the same line as previous year. A large number of spores of *Helminthosporium* and of *Alternaria* were trapped during the year under report. A teleutospore of *Puccinia* sp. was trapped for the first time during the third week of October. Viable uredospores of *P. graminis*, *P. rubigo-vera* and *Puccinia glumarum* were caught during the month of January almost 2-3 weeks before the appearance of rust on the standing crop in the Institute area. Spores of *Diplodia* sp., *Urocystis* sp., *Tolyposporium* sp. and moulds were mostly trapped during the month of December.

(iii) *Studies on Fungicides*.—Leaf extracts of *Calotropis gigantea*, *Bærrhaavia diffusa*, *Osimum sanctum* and *Adhatoda vasica* were tested against *Helminthosporium helodes*,

Alternaria solani, *Sclerotium rolfsii* and rusts. Only *A. vasica* showed fungicidal properties against all the fungi tested when 1% solution of Vasicine (extracted from *A. vasica*) was employed.

(iv) *Micro-flora in decomposing green manure plots*.—A preliminary experiment to determine the frequency of occurrence of micro-flora, specially species of *Mucor* and *Rhizopus* in the soil of plots green manured with sann-hemp (*Crotalaria juncea*), cowpea (*Vigna unguiculata*) and guara (*Cyamopsis psoraloides*) during October-November 1947 indicated that the frequency of occurrence of *Mucor* and *Rhizopus* spp. was greatest in the plot where sann-hemp was decomposing. Species of *Fusarium*, *Trichoderma*, *Curvularia*, *Helminthosporium*, *Aspergillus*, *Penicillium* and *Alternaria* were also commonly recovered.

(v) *Virulence of light strain of Collectotrichum falcatum*.—It has been established that light coloured strain of *C. falcatum*, is essentially more virulent than the dark strain. The parasitic activity of the two strains was compared on different canes as well as on the same canes. These experiments have been undertaken with a view to determine the causes of greater virulence of the light strain and reduced activity of the dark strain.

Section of Plant Viruses

1. TOMATO (*Lycopersicum esculentum* Mill.):

(a) *Latent Virus in Tomato*.—The virus is often carried symptomlessly in tomato. This virus could be recovered from a large number of tomato plants of variety "Sutton's Early Market" in the field including those affected by "smalling disease". The tomato plants in the insect-proof house developed very faint mottling 6-12 days after inoculation. At times the younger leaves of these plants appear pale. The symptoms, however, are transient and after the disappearance of the symptoms the plants look perfectly normal though the plants carry the virus throughout their lives. Infected tomato plants develop intracellular inclusions, that is, typical X-bodies and cubical crystals. The inclusions are usually more prominent in the epidermal hair. The host range of virus has been studied and it has been found that the virus is rendered innocuous by exposing the expressed sap to 59° C. for ten minutes. It withstands a dilution of up to 1: 10,000 and retains infectivity in extracted sap for 24 hours at room temperature. At one stage of the investigation the causal virus was suspected to be a weak strain of *Solanum virus 1*, but this view was discounted by the immunological tests carried out in this connection.

(b) "*Smalling*."—A serious disease of tomato characterised by pronounced smalling of the leaves has been observed at Delhi and in other tomato growing tracts for the last several years. The disease was particularly severe during 1946-47 and over 90% of the plants in early sown experimental plots were found to be infected. In later sowings, however, the incidence of the disease was much lower. The plants which get infected while young practically yield no crop. The disease has been found to occur year after year and during 1943-44 and 1944-45 over sixty varieties of tomato which were under trial for their resistance to virus diseases were found to be more or less infected by the disease.

The infected tomato plants of variety "Sutton's Early Market" in the first instance show marked stunting, clearing of the veins and reduction in leaf size. At the same time the plant exhibits typical mosaic symptoms which vary from mild to severe. The reduction of the leaves is more pronounced in the successive leaves and is accompanied by stunting of the internodes with the result that the leaves are found crowded together. The leaflets are deformed and their margins may curl inwards or outwards. In a few cases the young leaflets showed a tendency towards corkscrew distortion with the tips forming a type of a hook. Puckering of the leaflets is a common symptom of the disease. The plant has a tendency to produce stunted lateral branches which impart a bushy appearance. The disease induces partial or complete sterility of the infected plant depending on the stage at which infection has taken place. In cases of late infections the plant bears a few fruits but in earlier infections the symptoms are more pronounced and the few flowers that are formed bear reduced floral structures which never attain normal size. They seldom open and soon drop off.

The virus is not sap-transmissible but is readily transmitted by grafting. *Bemisia gossypiperda* has been established to be the vector of the virus. The disease was successfully transmitted to several varieties of tobacco, potato and certain other members of the *Solanaceae* family. It has been indicated that the virulence of the virus may be reduced during passage through tomato plants. Work in this direction is in progress. The causal virus has been identified as *Nicotiana virus 10*.

(c) *Bronzing*.—Preliminary observations have indicated that the plants exhibiting the symptoms are infected by a mixture of viruses, one of which is sap-inoculable whereas the other can be transmitted by grafting. The sap-inoculable virus has a thermal death point of 80° C. and in crude sap can tolerate a dilution of 1 : 10,000—1 : 15,000 and has a longevity *in vitro* of six days at a temperature of 15°-25° C.; the infectivity is, however, lost after 7 days' storage.

2. SANN-HEMP (*Crotalaria juncea* L.).

(a) *Mosaic*.—The virus which is sap-inoculable, has a thermal death point of 68°-70° C. and a longevity *in vitro* of 70-75 days at a temperature of 12°-15° C. The virus in the crude sap can tolerate a dilution of 1 : 500-1 : 1,000. The virus is not seed transmitted. Ultra-violet absorption studies were conducted both with sann-hemp and cowpea mosaic viruses. The absorption spectra were taken on a Hilger's Spekker Spectrophotometer. Samples of sann-hemp and cowpea mosaic viruses were collected and purified. The former virus was obtained in a crystalline form but in the case of the cowpea virus the crystals were not precipitated at the final stage and the solution as such was utilized for light absorption studies. Such preparations of cowpea mosaic virus retain their infective properties.

Absorption maximum due to protein is 2.800 A^u, while that due to nucleic acid component is 2.600 A^u. In all the samples of sann-hemp mosaic virus maximum absorption is seen at 2.700 A^u, which indicates that it is more towards the protein side. The virus contains unstable nucleo-proteins which lose different amount of nucleic acid due to hydrolysis in the preparation of different samples of the same virus. The absorption curve of cowpea mosaic virus is almost similar excepting that the maxima are generally slightly displaced towards longer wave lengths.

(b) *Smalling*.—Extreme stunting of the aerial organs associated with excessive branching and reduction in the length of the internodes and petioles is a characteristic feature of the disease. The infected leaves are much reduced in size and show mottling. Sterility is usually associated with the malformation. The virus is sap-inoculable and retains its infectivity after 10 minutes exposure to 85° C. but becomes innocuous after exposure to 90° C. for a similar period. The virus retains its activity after 41-50 days' storage at 12°-15° C. and in crude sap can tolerate a dilution of 1 : 25,000—1 : 30,000.

(c) *Leaf-curl*.—This disease is characterized by curling of varying degrees of whole or part of lamina, thickening of the veins and presence of outgrowths or enations along the veins on the under surface of diseased leaves. Abnormal twisting of the stem and branches is often associated with the disease. The virus is not sap-transmissible but can be successfully transmitted by grafting. Transmission has been successfully obtained on a wide range of host plants. The disease is not transmitted through the seed.

3. LETTUCE (*Lactuca sativa* L.).

Yellow Mosaic.—Yellow mosaic mottling and vein clearing are prominent symptoms of the disease. Old infected leaves are thick and leathery and often exhibit chlorotic areas along the margins. The virus is sap-inoculable and has been found to be seed transmitted. The virus remains infective after an exposure for 10 minutes to 86° C. but loses its infectivity when exposed to 87° C. for a similar period. In crude sap the virus can tolerate a dilution of 1 : 60,000—1 : 70,000 and remains infective when

stored for 60 days at room temperature (15°-25° C.). The infectivity is, however, lost after 64 days' storage. The host range of the virus has been studied.

4. GENERAL.

(i) *Brinjal*, (*Solanum melongena* L.).—*Empoasca devastans* has been found to be the vector of the virus. Experiments conducted to determine the incubation period in the vector are so far inconclusive.

(ii) *Crotalaria mucronata* Desv. (*C. striata* DC).—The mosaic disease in *Crotalaria mucronata* has been commonly observed at Delhi. The virus is sap-inoculable to *Crotalaria mucronata*, *C. juncea*, *Vigna unguiculata*, *Phaseolus mungo*, *P. radiatus*, but not to *Cajanus cajan*, *Vicia faba*, *Nicotiana tabacum* and *Lycopersicum esculentum*. The virus has a thermal death point of 80°-85° C., longevity *in vitro* of 134-142 days at 12°-15° C. and can tolerate a dilution of 1 : 20,000—1 : 30,000.

(iii) *Bottle-gourd* [*Lagenaria leucantha* (Duch.) Rusby].—Properties of the mosaic virus are being studied. The dilution end-point of the virus has been found to be 1 : 10,000. The virus retains its infectivity when exposed for one hour to 40-60 per cent. alcohol, and when treated with 1% nicotine or 0.1% mercuric chloride. The virus is active over a wide range of pH and its activity is not impaired after passage through Fuller's earth. The effect of different plant extracts on the infectivity of the virus is being studied. Preliminary experiments have indicated that extracts of *Datura stramonium* leaves have a deleterious effect on the infectivity.

(iv) *Bhindi* (*Hibiscus esculentus* L.).—A disease characterized by vein clearing particularly in young leaves, puckering, elongation and curving of the petioles has been observed. Enations are frequently observed on the undersurface of infected leaves. The disease is not sap-inoculable but can be transmitted by grafting. Experiments to determine the insect vector are in progress.

(v) *Knol-khol* (*Brassica oleracea* L. Var. *gongylodes* L.)—mosaic.—The virus is sap transmissible and has been successfully transmitted to cabbage plants of variety *Golden acre*. The virus has a thermal death point of 62° C., dilution end point of 1 : 100 and longevity *in vitro* of 6 hours.

(vi) *Potato* (*Solanum tuberosum* L.).—Necrosis.—Potato plants of variety *Darjeeling Red Round* raised from disease-free seed tubers developed severe necrotic symptoms. Necrosis of the foliage finally resulted in complete withering away of the plants. The casual virus is not sap transmissible but can be readily transmitted by grafting and by *Bemisia gossypiperda*. Besides, the potato virus has been transmitted to certain other plants. The causal virus has been identified to be a mild strain of tobacco leafcurl virus.

(vii) Transmission tests on mosaic of safflower and sterility of pigeon-pea have been undertaken. Attempts to inactivate *Solanum Virus I* in the potato sprouts by the application of moist heat without affecting the viability of the sprouts with a view to obtain disease free tubers were unsuccessful.

5. SEED POTATO MULTIPLICATION SCHEME.

Three thousand and twenty-six maunds of partially disease free seed potatoes stored in the cold store were distributed to Provincial and State Governments, Military farm depots and some growers for seed purposes. Reports regarding the performance of this material are not yet available. The performance of partially disease-free seed potatoes

distributed under the scheme in September-October 1946 has been extremely satisfactory from the point of view of disease incidence and outturn. At Farrukhabad the germination was 100% and the disease incidence did not exceed 1.2% as against 50-60% in the local crop raised from seed obtained from other sources by the growers. The maximum yield obtained from the seed supplied under the Scheme was 300 mds. per acre with an average of 220 mds. as against 150-200 mds. per acre obtained from seed received from other sources. The keeping quality of the seed has been reported to be better as compared to commercial seed.

6. SEED POTATO CERTIFICATION SCHEME.

The potato crop in certain selected areas in U. P., Bihar and East Punjab was examined for disease incidence. In U. P., potato varieties *Gola* and *Phulwa* were examined at Meerut and Hapur. The average disease incidence of severe types of virus diseases in *Phulwa* crop raised at Hapur from seed obtained from Farrukhabad was 61.5% whereas in the crop raised from seed obtained from Patna it was 12.5%. The *Phulwa* crop raised from seed distributed by this Institute showed a disease incidence of 2.7%. The *Gola* crop was infected up to 27.5%. Incidence of negligible types of mosaic varied from 35-63%. In Meerut area the average incidence of severe types of virus diseases in *Phulwa* and *Gola* varieties was 26% and 40% respectively, while the incidence of negligible mosaic was 69.5% and 30% in the two varieties. In Bihar the average incidence of severe types of diseases ranged from 2.24% while the percentage of infection due to negligible types of mosaic varied from 28-64%. In the hills of East Punjab mostly *Numbri* variety has been cultivated and the incidence of severe types of virus diseases varied from 5.5 to 7.5%; the incidence of negligible types of mosaic varied between 36.4% and 39.3%. The insect incidence in all localities inspected was also recorded.

Selection of virus-free material.—Tubers of apparently healthy plants of varieties *Darjeeling Red Round* and *Up-to-date* and potato hybrids 2, 9 and 12 which were selected and raised at the Central Seed Potato Certification Station at Kufri, during August-September, 1946, were again planted at Kufri in April-May 1947. The crop was examined at regular intervals and all undesirable plants were rogued out. The selected plants were harvested and collected during September-October 1947.

The selections raised at Kufri were grown in the insect-proof house at Delhi and tested on differential hosts. The tested and selected material was again planted at Kufri during April-May 1948 for further study and selection. Multiplication of *Darjeeling Red Round* and *Up-to-Date* varieties has been undertaken. Selection of virus-free material by raising plants from sprouts was continued and some plants of *Phulwa* variety have been selected by this method. In order to obtain disease-free plants of hybrids 2, 9 and 12, preliminary selections were continued to be made in the crop grown at the Potato & Wheat Breeding Sub-station at Simla.

Potato Test Plots.—Representative samples of tubers obtained from the test plots laid out during 1946-47 in different localities in U. P., Bihar and East Punjab with a view to obtain information on the relative spread of virus diseases, were planted in the experimental plots at Delhi. Individual plants were examined for virus diseases. Observations made in this connection indicate that the spread of virus diseases is minimum at Muzaffarpur in Bihar and maximum at Jullundur in East Punjab. In the U. P. the relative spread is less at Hapur as compared to Jaunpur and Farrukhabad.

Certain weeds, viz., *Malva verticillate*, *Arissema jackuemonitii*, *Geranium Robertia*

num and *Achyranthes bidentata*, have been observed to be infected with viruses in the potato fields in Simla hills. Tests to identify these viruses are in progress.

Taxonomy.

Studies in the genus *Colletotrichum* were undertaken and 13 new hosts have been established. Studies in the genus *Cercospora* have been started. Specimens received from the Mycologists of different Provinces were studied in detail and identified.

Indian Fungi Culture Collection.

Forty-one new cultures have been added to the Collection during the year under report while 111 cultures were supplied to various research institutes, universities and Industrial Concerns both in India and abroad. Description of fungi and information regarding the use of certain moulds in fermentation processes were also supplied. Investigations into improved methods of preservation of live-cultures were continued to be made. It has been observed that certain species of *Aspergillus*, *Penicillium*, *Helminthosporium*, *Alternaria* and *Curvularia* remained viable for 8 months in culture tubes to which sufficient quantity of "Nujol" or liquid paraffin to cover the fungal growth had been added.

Herbarium.

One hundred and twenty specimens from our Collection were supplied to various research and teaching institutions both in India and foreign countries. Four *Exsiccati* Sets, *Fungi Dakotensis*, *Fungi Columbiani*, North American *Uredinales* and *Fungi Scandinaviae* were added to the Herbarium. The total number of specimens in the Herbarium now exceeds 16,400.

III.—ADVISORY.

Enquiries from all over India and abroad on various subjects were attended to, as also identifications of pathogenic and taxonomic specimens were made for various research workers at their request and information regarding literature and distribution of fungi, etc., was supplied to them. In addition, a large number of scientific notes were prepared in connection with certain important enquiries, e.g., scope of microbiological methods for the estimation of substances of nutritional importance, the methods of assessing losses due to plant diseases, estimates of losses due to diseases in different countries and the beneficial effects of control measures. About 350 samples of seed and plants were examined, treated and necessary certificates of health were issued. Advice was given to the I. C. A. R. when called for and several papers intended for publication in scientific journals were examined and commented upon. A Scheme for the *Control of Wheat Rusts in India* was put up jointly with the Head of the Division of Botany for consideration of the Rust Control Committee of the Government.

IV.—TRAINING

During the year under report 7 students after successful completion of their course received Diploma of the Institute. Eleven students, eight in the first year and three in the second year, were under training in mycology, plant pathology and plant virus. A regular course of teaching was conducted by the specialist members of the staff and the necessary practical training imparted. To test the knowledge of the students terminal examinations were held. The second year students were allotted Research problems which they continued to investigate under the guidance of the senior members of the staff.

Two Research Fellows, one appointed by the Government and the other by the Indian Council of Agricultural Research, were admitted and they carried out research work under the direction of members of the staff depending on the nature of the problems allotted to them. In addition, three honorary research workers were provided with facilities for research and guidance by the members of the staff. Also two Short-Course students were admitted and giving training in mycology and plant pathology including viruses.

V.—MISCELLANEOUS.

Eight meetings of the research workers of this Division were held during the year under report when members of the staff and postgraduate students spoke on different aspects of their respective problems.

One hundred and ten exhibits were put up in the laboratory during the "Conversation Week" held in March 1948.

VI.—PROGRAMME OF WORK (1948-49).

I. Pathological investigations.

- (a) Studies on loose smut of wheat, Karnal Bunt and long smut of Jowar.
- (b) Determination of physiologic forms of *Ustilago tritici* (Pers.) Rostrup, *Collectotrichum falcatum* Went., and *Ustilago scitaminea* Sydow.
- (c) Studies on rusts of wheat, gram, safflower, lentil and linseed.
- (d) Wilt diseases of gram, pigeon-pea, linseed and lentil. Early and late blight of potato. Diseases of other economic crops.
- (e) Testing for disease resistance of varieties of crops evolved at this Institute.
- (f) Diseases of sugarcane. Varietal resistance to red rot and smut. Estimation of losses due to plant diseases.
- (g) Studies in antibiosis, microbial antagonism. Physiology of parasitism and fungicides.
- (h) Bacterial diseases of plants.

II. Plant Viruses.

- (a) Virus diseases of solanaceous, leguminous, cucurbitaceous and cruciferous plants.
- (b) Purification and ultra violet absorption studies of sann hemp mosaic and allied viruses.

- (c) Study of insect vectors.
- (d) Selection of virus-free seed tubers, tuber indexing and multiplication of disease-free tubers.

III. Mycological investigations.

1. Taxonomy of fungi with special reference to rusts, smuts and genus *Colletotrichum*.
2. Maintenance of the Indian Type Culture Collection of fungi and investigations to evolve improved methods of preservation of fungi. Additions to and maintenance of the Herbarium.
3. Identification of fungi and diseased specimens.

IV. Miscellaneous.

1. Maintaining a host index of fungi.
 2. Preparation of card index of species of fungi represented in India.
 3. Maintaining an up-to-date card index of literature on plant pathology including viruses.
 4. Training of postgraduate and other students.
 5. Advice and assistance to the I. C. A. R.
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Report of the Head of the Division of Agricultural Engineering

I.—INTRODUCTORY.

The work of the Division continued on a restricted scale, due to, during the major portion of the year, the non-availability of suitable skilled personnel and to the fact that the new workshops and other buildings have not yet been erected. The procurement of equipment, machine tools and apparatus continued.

The first of certain machinery ordered for experiments in the design of small mills for use in Rural areas for the utilization of sun-dried bones has arrived.

Two small threshers, now extensively used in Holland on small holdings, have arrived for trial and test with a view to ascertaining their economic and practical possibilities of usage by small cultivators or groups of cultivators under Indian conditions.

A new type of Bullock gear, capable of driving small pumps, threshers, winnowers, etc., has been designed. It is compact and simple and can be used in conjunction with any existing Persian wheel.

Extensive field trials have been carried out over periods exceeding 1,000 hours on various types of tractors. Complete tables showing operational costs and rates are given later in the report.

An interim report on the working under local conditions of a small H. P. walking type tractor is also given.

It is considered that the testing under Indian conditions of implements and machinery manufactured abroad is important and essential. These machines, designed in principle for the conditions prevailing in their country of origin, may not prove either a practical or economic proposition when worked under extreme climatic and exacting conditions as exist in this country.

II.—RESEARCH.

(A) WATER FILLED TYRES.

Preliminary experiments have been undertaken to consider the advantages and economics of the filling of pneumatic tyres fitted to country carts with water in lieu of air.

It had been noticed that pneumatic tyres fitted to country carts lived, in most cases, an extremely short life, at the end of which they were discarded as unserviceable although treads were in good condition, due to break down of tyre walls. The average bullock driver does not worry about his tyres until they are more or less flat and are often used in a semi-inflated condition on farm and country roads where bumping effects are accentuated and soon destroy tyre walls.

The results of filling with water (100%) have so far given remarkable results. On one cart, two tyres with inner tubes filled with water to normal working pressure have given six months continuous service to date without appreciable reduction in pressure. Two sets of similar tyres and tubes, air filled, used as control during this period

and subjected to similar usage have been punctured many times and their serviceable life greatly reduced due to damage to their walls. In connection with the additional total net weight of the cart due to weight of water in the tyres it has been found that average draw bar pulls under various road conditions are lower due to decreased rolling resistance of properly inflated tyres. A series of carts are to be the subject of a full scale detailed trial during the current year.

Note.—The present method of filling of water is by a special two action pump, exhaustion of air the first operation, water filling the second. This pump is an expensive item but it is hoped that an improvised pump will be designed and perfected coincident with the new trials.

(B) KANS CONTROL EXPERIMENTS AT BHOPAL.

The following is a brief summary of the first year (1946-47) results.

The scheme was undertaken to investigate the most effective methods of controlling Kans and the main objects of the experiments were:—

- (a) To observe the effects of various cultivations immediately after deep ploughing on Kans reinfestation.
- (b) To discover the most suitable rotation to rebuild soil fertility and at the same time to act as a deterrent to the re-emergence of Kans, and
- (c) Cost of initial deep ploughing.

A heavily Kans infested area near Bhopal which had previously gone out of cultivation was selected and an area of 96 acres of it tractor-ploughed to an average depth of 12" starting on May 11 and finishing June 5th.

- (1) Out of this, 18.90 acres, ploughed earliest in the season, were subjected only to dessication.
- (2) In 28.02 acres the ploughed up rhizomes of Kans were picked up and the area beamed.
- *(3) In 27.54 acres beaming alone after ploughing was carried out.
- (4) 5.23 acres were double ploughed.

In each of these areas the following cropping schemes, repeated 6 times were followed:—

A.	Sanai (seed rate 80 lbs. per acre)	...	...	Wheat.
B.	Sanai (seed rate 100 lbs. per acre)	...	...	Wheat.
C.	Cultivated fallow	...	...	Wheat.
D.	Guar fodder	...	...	Gram.
E.	Juar Arnar	...	...	Gram.
F.	Paddy	...	...	Wheat.
G.	Rameli (seed rate 6 lbs. per acre)	...	...	Gram.
H.	Hameli (seed rate 12 lbs. per acre)	...	...	Gram.

The data obtained has been summarized in Tables I to IV,

Table 2 gives the estimates of Kans infestation taken before ploughing in the month of May and after the harvesting of the Rabi crops. The table shows that the percentage of Kans shoots after cropping, to that before plotghing, varied from 1.54 to 6.29. Of all the treatments, those under double ploughing, and picking and beaming, Kans reinfestation is least.

Table 3 shows the number of Kans shoots and length of Kans rhisomes after cropping as a % of these prevailing before ploughing in the various crop rotations. It is seen definitely that the reappearance of Kans is least in the case of cropping with paddy followed by wheat. Next in order the rotations with Sanai would appear to be better than other treatments from the point of prevention of the reappearance of Kans.

Table 1 gives yield data. The rotation Sanai-wheat is as good as fallow-wheat judging from wheat yields. An average yield of 5.85 maunds per acre of wheat and 8.8 maunds per acre of gram were realized. Maximum yields realized being 13.5 maunds per acre and 18.8 maunds per acre respectively.

The cost of deep cultivation is presented in Table IV and gives a final figure of Rs. 20.37 per acre.

The results of the 2nd year's work are to be incorporated with the full first year's results and form the subject of a detailed and final report.

TABLE 2.
Kans infestation.

Treatment	pre-ploughing infestation				Pre-ploughing and Post-ploughing infestation (after Rabi harvest)				post-ploughing infestation Post-ploughing estimate as % of pre-ploughing estimate			
	A	S.D.A	B	S.DB	A	S.D.A	B	S.DB	A	S.D.A	B	S.DB
1. Dessication	99	40	110.41	47.01	6.23	3.37	6.77	4.86	6.29	8.43	6.13	10.34
2. Double-ploughing	99	40	110.41	47.01	1.52	1.41	4.11	3.55	1.54	3.53	3.72	7.55
3. Picking Kans and beaming	106	36	107.10	30.73	3.00	2.28	4.02	2.74	2.78	6.33	3.75	8.92
4. Beaming only	106	32	111.72	31.38	6.50	3.73	5.65	3.79	6.13	11.66	5.24	12.08
5. Non-Experimental area	99	40	110.41	47.01	2.35	2.61	5.48	6.86	2.37	6.53	4.96	14.59

A = Average total number of Kans shoots in 9 sq. ft.

S. D_A = $\frac{3}{4}$ standard Deviation B_A

B = Average total length of Kans Rhisomes in 9 c.ft.

S. D_B = Standard Deviation of B.

TABLE 3.
Effect of Rotation on the re-emergence of Kans.

Rotation	No. of shoots of Kans after cropping as % before ploughing	Total length of Kans shoots in 9 c.ft. after cropping as % of length before ploughing
A. Sanai (80 lbs. per acre-wheat)	...	3.65
B. Sanai (100 lbs. per acre-wheat)	...	3.41
C. Fallow-Wheat	...	4.89
D. Juar fodder-Gram	...	5.12
E. Juar Arhar Grain	...	4.10
F. Paddy-Wheat	...	2.41
G. Rameli-Gram 6 lbs. per acre	...	4.10
H. Rameli-Gram 12 lbs. per acre	...	6.31

TABLE 1.
Average yield of Rabi@ and Kharif × crops (in Mds. per acre) under different treatments and Rotations.

Rotation	Description		Ploughings		Picking of Kars		Beaming alone		Mean	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
Sanai (80 lbs.) per acre.	...	6.57	...	8.19	...	6.86	...	7.55	...	7.29
A—Wheat	...	...	...	...	...	...	...	...	...	...
Sanai (100 lbs. per acre).	...	5.19	...	6.71	...	8.02	...	7.84	...	6.94
B—Wheat	...	...	...	...	...	...	...	...	...	...
Fallow—Wheat	...	6.34	...	7.87	...	6.70	...	7.33	...	7.06
Paddy—Wheat	...	2.15	...	1.75*	0.63	2.10	0.72	2.07	...	2.11
Mean	...	5.06	...	7.59	0.63	5.92	0.72	6.20	...	5.85
Juar fodder	...	13.94	...	11.43	...	12.90	...	12.42	...	12.67
Gram	...	...	...	...	...	...	...	...	...	...
Juar Arhar	...	14.03	...	10.00	...	13.88	...	15.55	...	13.37
Gram	...	...	...	...	...	...	...	...	...	...
Rameli (6 lbs. P/a) ...	1.73	2.55	1.24	0.56	1.29	5.28	...	11.50	...	4.72
Gram	...	...	...	...	...	...	...	...	...	...
Rameli (12 lbs. P/a) ...	1.76	3.10	1.24	0.51	0.79	2.76	...	11.78	...	4.54
Gram	...	...	...	...	...	...	...	...	...	...
Mean	1.75	8.41	1.24	5.63	1.04	8.71	...	12.81	...	8.83

* Peas.

@ Yields of wheat were low due to rust incidence which caused damage estimated at 80% throughout the whole of the State.

× Heavy and continuous rain in July and August resulted in complete failure of all crops.

TABLE 4.

Cost of Tractor ploughing.

Tractor (International Harvester T.D. 14 D.B.H.P. 54)					
Total area ploughed	...	...	...	...	= 129.33 acres inclusive of non-experimental area.
Average depth of ploughing	...	...	...	...	= 12"
Total No. of working hours	...	...	...	...	= 287½ hours.
A. Cost of Labour.					
1. Wages of one driver mechanic for 2 months at Rs. 250/- P.M.	...	...	...	...	Rs. 500 0 0
2. Wages of Assistant driver for 2 months at Rs. 125/- P.M.	...	...	...	...	Rs. 250 0 0
Total				...	Rs. 750 0 0
B. Miscellaneous.					
1. Repairs, maintenance and spares.	...	...	...	...	Rs. 150 0 0
2. Depreciation (Based on 8,000 hours life)	...	...	...	...	Rs. 898 7 0
Total				...	Rs. 1048 7 0
C. Running costs.					
1. High speed Diesel oil	...	...	...	...	= 706½ gal. = 739 10 0
2. Petrol	...	...	...	...	= 9 gal. = 18 9 0
3. Engine lubricating oil	...	...	...	...	= 22½ gal. = 55 8 9
4. Gear oil	...	...	...	...	= 3 gal. = 9 8 3
5. Grease	...	...	...	...	= 13½ lbs. = 4 8 7
6. Cotton waste	...	...	...	...	= 3 2 5
7. Kerosine oil	...	...	...	...	= 4 gal. = 5 0 0
Total				..	Rs. 835 15 0
Total expenditure					
	...	...	...	= A	Rs. 750 0 0
				B	Rs. 1,048 7 0
				C	Rs. 835 15 0
Grand Total					Rs. 2,634 6 0

Cost of deep ploughing acre Rs. 20.37 per acre.

(C) LOW H. P. TRACTOR OPERATION.

With a view to investigating the economic and practical possibilities of operation in this country of low H.P., air cooled, walking type tractors, a series of trials and tests were carried out on a "Gravelly" 5 H.P. tractor. The period under report was confined to two operations only, namely the harvesting of various crops and the usage of the tractor as a prime mover for the operation of small type threshers. After a total running period of less than 150 hours the tractor required a major overhaul due to excessive wear of cylinder, piston rings and burnt valve seatings.

During this test period numerous weaknesses in design developed, which included a badly fitting needle valve on the carburetter which continuously worked out of correct setting adjustment due to vibration and had to be finally replaced by a modified type which could be fixed in any desired position; the straps holding the petrol tank failed to withstand vibration, similarly the fan mounting, which is of very weak construction. Trials were carried out in shade temperatures varying from 90°-110° F. shade and at all times strict attention was paid to oil levels, oil replacement, greasing and routine maintenance.

The effort required by the operator is very marked and generally it was not possible for a man to operate the tractor continuously for more than one hour, at the end of which time he was completely exhausted, due in the main to operation in small sized plots which necessitated constant turning and also lifting of implement to negotiate bunds and channels.

Overall petrol consumption averaged $\frac{1}{2}$ gallon per hour, practically double that claimed by the manufacturers.

The following are summarised results of tests:—

- (1) Tractor, using belt pulley attachment for operation of small peasant threshers; capacity $2\frac{1}{2}$ maunds threshed grain per hour.

Operating period	Total actual operating period (hours)	Total petrol consumption (gallons)	Petrol consumption per hour (gals).
7-5-1948 to 31-5-48 inclusive	108.6	46.26	.426

- (2) Tractor with sickle cutter attachment used for cutting of oats, berseem, wheat and gram crop.

Operating period	Total actual operate period (hours)	Total acreage completed	Petrol consumption (gal)	Acres per hour	Petrol per acre (gal)	Petrol per hour (gal).
2-4-1948 to 3-5-1948 inclusive	28.71	12.59	16.4	.439	1.3	.573

It would appear, from the remarks and results give above, that this type of tractor will not be an economic or practical proposition when operated under extreme climatic conditions as exist in this country. Only by having good workshop facilities constantly available was it possible to keep machine in operation. The working life of the engine, based on this initial test is limited and vibration throughout the whole tractor is excessive.

While the actual work performed at any one time is good from a practical and operational rate point of view, inability of the tractor to continue this for any economic period makes it difficult at this stage to recommend it.

A full and detailed report on the working summarised above is in course of preparation and further tests and trials are to be continued.

(D) ROTATORY SCREEN.

A proposal to utilize decomposed materials, available in large quantities in town refuse dumps necessitate the design and experiment of a suitable mechanical screen for the purpose.

The requirement of the screen was to produce, in economic quantities, a final product suitable in grade for easy application to the land and free of broken glass, metal pieces, stones other unwanted material. In operation, when processing material of high moisture content it must not clog. It must break up or pulverize to a certain extent larger lumps of decomposed material to prevent them being rejected. An experimental screen, fulfilling above requirements has been designed and tested and has produced an excellent final product and, although of small dimensions is capable, by manual labour of producing 80-100 maunds of finished material per hour.

In the first experimental model to be tried, screen produced three distinct samples, viz., a finished product (sample I), and intermediate (sample II) rejected material (sample III) in the proportion of approx. 60% to 15% and 25% original bulk. Physical and chemical analysis of composite samples of these three resulted as follows:—

Sample I (Chemical analysis).

Moisture	...	...	...	...	9.29%
Loss in ignition	...	...	...	...	10.84%
Nitrogen	...	...	...	...	0.878%
Phosphoric acid P_2O_5	...	...	...	...	1.712%
Potash K_2O	...	...	...	...	1.39%

Sample III (Physical analysis).

Undecomposed organic matter	...	...	...	16.6%
Stones glass, etc.	...	...	...	61.00%
Rags—leather	...	...	...	18.90%
Iron and other material	...	...	...	3.50%

Sample II (Physical analysis).

Undecomposed organic matter	...	...	...	64.90%
Stones and other refractory material	...	...	...	35.10%

Sample I compares well with good quality compost.

As a result of these analysis, screen was modified to produce only two samples, finished product and unwanted material, such modification incorporating into sample No. I a percentage of the undecomposed organic matter from No. II sample.

Under test this modified screen gave excellent results, with a slightly higher output and the chemical and physical analysis of the two products which were in the proportion of 85% and 15% of organic bulk were as follows:—

Sample I (Chemical analysis).

Moisture	...	...	...	...	25.6%
Loss in ignition	...	...	...	...	16.5%
Nitrogen	...	...	...	...	0.9%
CaO	...	...	...	...	6.12%
K_2O	...	...	...	...	2.27%
P_2O_5	...	...	...	...	1.60%

Sample II (Physical analysis).

Stones, etc. ...	...	...	62.7%
Undecomposed organic matter ...	...	...	11.6%
Iron pieces ...	...	...	2.4%
Sand and decomposed matter ...	...	...	23.3%

Experimental screen is now undergoing full working trials and any modifications still found necessary will be incorporated in the design of a commercial model now being planned.

(E) TRACTOR TRIALS.

Tests were carried out on various tractors in order to ascertain their operation rates and costs. Type of tractors tested were confined to those in use, or will be used on medium and small holdings.

Although costs of tractor operation vary under different ownerships and in different districts due to factors such as type of land, maintenance and general care and number of hours worked, the figures given in the following tables can act as a general guide and in the absence yet in this country of published and established tractor operating costs and rates may perhaps be of value.

Such tests are being continued and subsequent figures will be of interest as tractors age and costs under repairs and maintenance head tend to rise.

TRACTOR COMPARATIVE OPERATIONAL RATES AND COSTS.*Tractor Operating Costs.*

	D-4 (No. 1) Caterpillar Tractor	D-4 (No. 2) Caterpillar Tractor	Oliver '60' Row crop Tractor	Farmall Row crop Tractor
Total usage (hours)	1,474	1,607	713	774
Purchase price	Rs. 10,000	Rs. 10,000	Rs. 44,500	Nil
1. Labour*	790	863	390	472
2. Fuel H. S. diesel	1,856	1,728	...	...
3. Fuel petrol	80	91	160	106
4. Fuel Kerosine oil	23	22	646	1,121
5. Lubricating oils	496	465	139	130
6. Repair & servicing	423	436	101	1,730 @
7. Depreciation=	1,854	1,910	400	... +
8. Total	5,522	5,515	1,896	3,559
9. Cost per hour	3.7	3.4	2.5	4.6 &

* Based on present hourly cost of skilled Tractor Driver and a mate

= Based on a working life of 8,000 hours.

+ This tractor is 12 years old and the capital cost has been completely written off.

@ Cost of complete new engine, radiator etc.

& High on account of @ but in subsequent years will be at least 50% down.

Operational Rates and Costs.

	D-4 No. 1 Tractor				D-4 No. 2 Tractor				Oliver (60)				Farmall Roaw crop			
	Hours	Acres	Acres per hour	Cost per Acre	Hours	Acres	Acres per hour	Cost per Acre	Hours	Acres	Acres per hour	Cost per Acre	Hours	Acres	Acres per hour	Cost per hour
1. Discing	662	1192	1.8	2.06	823.5	1545.7	1.87	1.81	21.5	22.5	1.05	2.38	41.5	54.9	1.32	3.48
2. Grubbing	321.5	568.37	1.76	2.10	207.5	293.47	1.41	2.41	173.5	284.0	1.64	1.52	12.4	15.5	1.25	3.68
3. Ploughing	81	55.68	.69	5.36	282.5	200.5	.71	4.80	25.0	16.0	.64	3.90	...	...	...	...
4. Mowing	110	87.0	.79	4.68	50.0	48.0	.96	3.53	174.9	189.6	1.08	2.31	...	...	...	...
5. Drilling	...	...	...	...	4.0	6.75	1.68	2.02	41.5	31.6	.76	3.29	17.0	14.2	.84	5.5
6. Road work & idle running	298.8	...	...	...	239.0	...	...	...	85.6	...	...	...	17.5	...	...	...
7. Stationary work (threshing etc).	...	...	...	...	...	...	...	...	191.0	...	...	...	686.0	...	...	...
	1473.3	1903.05			1606.5	2094.42			713.0	543.7	...	...	774.4	84.6		

III.—ADVISORY.

The number of postal and personal enquiries relative to mechanization continued to greatly increase. Many of these enquiries ask for advice regarding various manufacturers advertised machinery and implements and information relating to its performance both practical and economic.

IV.—PROGRAMME OF WORK (1948-49).

1. *Usage of walking and other low H.P. tractors*—
 - (I) Tests and trials.
 - (II) Suggested modifications.
 - (III) Conclusions and recommendations.
 2. *Pneumatic tyres on country carts*.—Full scale tests and trials subsequent to preliminary good results of water filled in lieu of air.
 3. *Rotary screen for utilization of rotted materials from refuse dumps*.—Tests, trials, etc., of final mechanised design.
 4. *New type Bullock Gear*.—Manufacture—test and trial.
 5. *Tractors—Various*.—Field tests and trials.
 6. *Water Lifts*.—Field trials.
 7. *Threshing Machines (small)*.—Field trials and modifications.
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APPENDIX I.

Gazetted Staff of the Institute

Director.	Dr. J. N. Mukherjee, C.B.E., F.N.I., F.R.A.S.B., F.C.S.	
Assistant Director.	Dr. B. P. Pal, M.Sc., Ph.D. (Cantab), F.N.I., F.L.S.	
Registrar.	Mr. N. C. Pal, M.A., B.L.	Assumed charge of this newly created post on 17th October, 1947.
Personal Assistant to the Director.	Mr. J. M. Banerjee, M.A.	Took over charge from 1st November, 1947.

AGRONOMY

Head of the Division	Dr. T. J. Mirchandani, M.Sc., Ph.D.	Held the post from 27th November, 1947, except from 13th June to 5th July, 1948, when he went to U. K. to attend International Conference.
Agronomist.	Dr. P. C. Raheja, M.Sc., Ph.D.	Held the post from 15th July, 1947. He was transferred to the Agricultural Substation, Karnal on 23rd April 1948. Also held charge of the Division from 15th July to 26th November, 1947.
Agronomist.	Mr. S. Sen, M.Sc.	Held charge throughout the year. Also held charge of the Division from 13th June to 5th July, 1948.
Assistant Agronomist.	F Lt. R. D. Verma, B.Sc., B.Sc. (Hons), Agr. (Edin).	Joined the post on 13th August, 1947.
Assistant Agrostologist.	Mr. P. M. Dabadghao, M.Sc.	Joined the post on 4th September, 1947.
Assistant Statistician.	Mr. M. V. N. Rao, M.A.	Held charge of the post from 1-8-47.
Cattle Supdt.	Mr. N. P. Fernandez, G.B.V.C.	
Assistant Agronomist (Karnal).	Mr. B. D. Ganguly, B.Sc. (Agr).	Joined this Division on 13-10-47 and was transferred to the Substation, Karnal on 30-10-47. Also held charge of the Substation, from 1-11-47 to 25-4-48.

— do —	Mr. Y. C. Gupta, B.Sc. (Agr).	Held charge of the Substation from 21-4-46 to 30-10-47 and held the post upto 1-4-48.
— do —	Mr. A. R. Khan, B.Sc. (Agr)., M.Sc.	Joined the post on 2-4-48 and was transferred to Pusa on special duty.
Cattle Supdt. (Karnal).	Mr. U. P. Saha, G.B.V.C.	

BOTANY

Head of the Division.	Dr. B. P. Pal, M.Sc., Ph.D. (Cantab), F.N.I., F.L.S.	Held charge of the Division throughout the year except for 46 days from 4-2-48 to 20-3-48 when he was on earned leave.
Cytogeneticist (formerly designated as Second Economic Botanist).	Vacant.	
Geneticist.	Dr. N. Parthasarathy, B.A., B.Sc. (Ag.), Ph.D. (Lond.)	Took over charge on 1-11-47.
Plant Physiologist.	Dr. R. D. Asana, M.Sc., Ph.D. (Lond.), D.I.C.	Held post throughout the year except for 21 days from 24-5-48 to 13-6-48 when he was on earned leave.
Systematic Botanist.	Vacant.	
Assistant Geneticist. (formerly designated as Assistant Economic Botanist).	Mr. R. B. Deshpande, M.Ag., Assoc., I.A.R.I.	Held the post except for one month and seven days from 7-6-48 being on leave.
Asstt. Geneticist (formerly designated as Asstt. Botanist).	Mr. A. B. Joshi, M.Sc., Assoc., I.A.R.I.	Held the post upto 31-7-47 after which the post has remained vacant.
Asstt. Cytogeneticist.	- do -	Took over charge on 1-8-47. He held this post upto 14-8-47 prior to sailing for higher studies abroad.
Asstt. Plant Physiologist (formerly designated as Second Asstt. Economic Botanist).	(1) Mr. J. J. Chinoy, M.Sc., Ph.D. (Lond.), D.I.C. (2) Mr. T. J. Malkani, M.Sc.	Upto 15-7-47. From 3-5-48 (vacant from 16-7-47 to 2-5-48).
Asstt. Botanist (Plant Introduction Scheme).	Mr. H. B. Singh, M.Sc., Assoc. I.A.R.I.	Has held the post from 15-5-47.
Asstt. Botanist (Maize Crop Improvement Scheme).	Vacant.	

Supdt. & Potato Research Officer, Potato Breeding Station, Simla.	Dr. Pushkar Nath, M.Sc., Ph.D.	The post is temporary.
Asstt. Botanist (Geneticist), Potato Breeding Station, Simla.	Mr. D. Srinivasachar, M.Sc., Assoc. I.A.R.I.	- do -
Supdt. Botanical Substation, Pusa.	(1) Mr. S. M. Umar, M.Sc. (2) M. D. Nandkeoliyar, M.Sc. (Ag.)	Upto 14-8-47 when he left for Pakistan. From 7-6-48.

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Head of the Division.	Vacant.	
Soil Microbiologist I/C. of the Division.	Dr. S. V. Desai, B.Sc., Ph.D. (Lond.), D.I.C.	Upto 13th March 1948 when he proceeded on long leave and Director took over charge of the Division.
Soil Microbiologist.	Dr. S. V. Desai, B.Sc., Ph.D. (Lond.), D.I.C.	Upto 13th March 1948 after which the post remained vacant.
Organic Chemist.	Dr. R. H. Siddique, M.Sc., Ph.D.	Officiated upto 14th August 1947 when he opted for Pakistan.
Soil Survey Officer.	Dr. R. V. Tamhane, B. Ag. (Bom.), Ph.D. (London).	Officiating.
Physical Chemist.	Vacant.	
Biochemist.	Vacant.	
Asstt. Soil Survey Officer.	Dr. K. V. S. Satyanarayana, B.Sc., (Agr.), Ph.D., Assoc. I.A.R.I.	
Asstt. Soil Survey Officer.	Mr. L. M. Mathur, M.A., B.T., A.S.T.	Officiating from 10-5-48.
Asstt. Soil Chemist.	Dr. W.V.B. Sundar Rao, M.Sc., (Hons.), Ph.D., Assoc. I.A.R.I.	
Asstt. Soil Microbiologist.	Dr. N. D. Vyas, M.Sc., Ph.D. L. Ag.	
Asstt. Agricultural Chemist.	Dr. S. Das, M.Sc., D.Sc.	Upto 9-10-47 when he was granted leave preparatory to retirement.
	Mr. U. Sen Gupta.	Held charge of the post from 10-10-47 to 17-12-47.
	Mr. M. A. Idnani, B.Sc., Assoc. I.A.R.I.	Officiating from 18-12-47.

Asstt. Physical Chemist.	Dr. B. B. Roy, M.Sc., (Dac.), Ph.D., A.R.I.C.	From 23-6-48.
Asstt. Soil Physicist.	Mr. A. C. Ukil, M.Sc.	Upto 2-10-47. The post is vacant since then.
Asstt. Organic Chemist.	Vacant.	

ENTOMOLOGY

Head of the Division.	Dr. E. S. Narayanan, M.A., Ph.D. (Lond.), D.I.C. (Lond.), F.R.E.S., B.B.K.A.	Officiating from 22-6-48, Dr. Taskhir Ahmad officiated in this post upto 1-8-47 when he left for Pakistan. The post remained vacant from 2-8-47 to 21-6-48.
Ecologist.	Vacant.	
Parasitologist.	Dr. E. S. Narayanan, M.A., Ph.D. (Lond.), D.I.C. (Lond.), F.R.E.S., B.B.K.A.	Was appointed substantively to this post from 29-8-47 and held charge upto 21-6-48.
	Vacant.	From 22-6-48.
Systematic Entomologist.	Dr. S. Mukerji, M.Sc., D.Sc.	From 17th June, 1948.
Toxicologist.	Dr. S. Pradhan, M.Sc., B.Sc., (Hons.), Ph.D. (Lond.), D.Sc., (Luck.), F.R.E.S.	Officiating from 21-6-48.
Biological Control Research Officer.	Dr. E. S. Narayanan, M.A., Ph.D. (Lond.), D.I.C. (Lond.), F.R.E.S., B.B.K.A.	The post is temporary. Officiating upto 28-8-47. The post remained vacant from 29-8-47 to 26-3-48.
	Dr. S. Mukerji, M.Sc., D.Sc.	Officiated from 27-3-48 to 17-6-48.
	Vacant.	The post is vacant from 18-6-48.
Asstt. Systematic Entomologist.	Mr. B. B. Bose, B.Sc.	Officiating.
- do -	Mr. C. K. Samuel, B. Sc., Assoc. I.A.R.I.	Officiating.
Asstt. Insect Physiologist.	Dr. S. Mukerji, M.Sc., D.Sc.	Held this post upto 26-3-48.
	Vacant.	From 27-3-48.
Asstt. Insect Epidemeologist.	Dr. R. D. Menon.	Officiated upto 3-11-47. The post remained vacant from 4-11-47 to 18-3-48.

	Dr. S. Pradhan, M.Sc., B.Sc. (Hons.), Ph.D. (Lond.), D.Sc. (Luck.), F.R.E.S.	Took charge of this post from 19-3-48 and remained in this post upto 20-6-48.
	Vacant.	From 21-6-48.
Asstt. Sugarcane Entomologist.	Mr. T. V. Venkataraman, B.A., M.Sc., F.R.E.S.	The post is temporary, and remained vacant upto 10-8-47. Held charge from 11-8-47.

MYCOLOGY

Head of the Division.	Dr. R. S. Vasudeva, D.Sc., (Lond.), Ph.D. (Lond.), D.I.C.	Officiating from 22-6-48. Mr. J. F. Dastur Officiated in this post upto 30-9-1947.
Virologist.	Dr. R. S. Vasudeva, D.Sc., (Lond.), Ph.D. (Lond.), D.I.C.	Incharge of the Division from 1-10-47 to 21-6-48 in addition to his own duties.
Systematic Mycologist.	Vacant.	
Seed Potato Production Officer.	Vacant.	Post abolished from 1-2-48.
Asstt. Systematic Mycologist.	Dr. B. L. Chona, Ph.D. (Lond.), D.I.C.	Upto 31-3-48.
	Dr. M. K. Hingorani, B.Sc., Assoc. I.A.R.I., Ph.D. (Minnesota).	Officiating from 1-4-48.
Asstt. Virologist.	Mr. S. P. Ray Choudhuri, M.Sc., Assoc. I.A.R.I., F.I.S.	From 1-8-47.
Asstt. Plant Patho- logist.	Dr. R. Prasada, M.Sc., D.Sc., (Agra.)	Held charge throughout year.
Asstt. Plant Patho- logist.	Dr. M. L. Gattani, M.Sc., Ph.D. (Minnesota).	From 22-9-47.
Asstt. Plant Bacterio- logist.	Vacant.	

AGRICULTURAL ENGINEERING

Head of the Division.	Major D. T. Brown, A.M.I., Mech. E., M.I.B.A.E.
Asstt. Engineer.	Mr. A. K. Kaul, L.E.E.
- do -	Mr. K. S. Chopra, A.M., M.E.E.
- do -	Mr. A. D. Chhugani, B.E. (Mech.)

SUGARCANE BREEDING STATION, COIMBATORE

Sugarcane Expert	Mr. N. L. Dutt, M.Sc., F.A.Sc.	
Second Cane Breeding Officer.	Dr. N. Parthasarathy, B.Sc., (Agri.), Ph.D. (Lond.)	Upto 30-10-47.
Botanist (Class I)	Vacant.	
Asstt. Sugarcane Expert.	Mr. M. K. Krishnaswami, M.A.	
Plant Physiologist.	Mr. N. D. Yusuf, M.Sc. (Cantab.) Vacant.	Upto 14-8-47. The post is temporary.
Asstt. Botanist.	Mr. S. K. Mukherjee, M.Sc.	From 1-8-47. The post is temporary.
Chemist (Class II).	Mr. K. V. Gopala Iyer, B.A., (Dip.), T. I.	From 22-12-47. The post is temporary.

APPENDIX II

Training of Students and Research Workers

(a) List of students awarded Post-Graduate Diploma.

Name of student.	Title of Thesis.
AGRICULTURE	
1. G. Kishore	Study of the residual effect of N, P, K, and Ca alone and in combination applied to kharif legumes on wheat.
2. M. G. Ponnappa	(a) Kharif legume — Cowpeas.
3. M. M. Jain.	(b) - do - - do - — Soyabean.
4. K. N. Sharma	(c) - do - - do - — Guar.
5. P. M. Kochappa Menon	(d) - do - -do - — Moong.
6. T. Valauthan	Comparison of the residual effect of N, P, K alone and in combination applied cowpeas in the kharif with effect of N fertilizer applied to wheat direct.
7. G. N. Raut	Study of the direct effect of N, P, K alone and in combination on rabi legumes.
8. D. A. Weerasinghe	(a) Berseem.
9. S. Sen	(b) Senji
	(c) Gram
	(d) Peas
SUGARCANE BREEDING	
10. S. Fasilhi	The influence of temperature and photo period on the germination of sugarcane seed.
11. S. K. Sastry	Morphological and growth studies in certain <i>S. officinarum</i> and <i>S. spontaneum</i> hybrids and the determination of chromosome numbers of parents and hybrids.
12. A. M. Khan	Morphological and anatomical studies in certain sugarcane hybrids (<i>Co. canes</i> and determination of their chromosome numbers).
BOTANY	
13. S. R. Bhargava	Variability and the role of natural selection in wheat mixtures and hybrid germination.
14. B. S. Joshi	Colchicine-induced polyploidy in crop plants <i>sesamum</i> . Study of the comparative growth and development in diploid and autotetraploid <i>S. orientale</i> L. (I.P.S.).
15. W. T. Butany	Influence of late sowing dates on yield and other plant characters in wheat varieties.
16. S. L. Tandon	Colchicine-induced polyploidy in crop plants <i>Brassica</i> . Study of the comparative growth and development in diploid and autotetraploid <i>B. campestris</i> var. <i>sarson</i> .
17. G. Venkataratnam	Cytology of autotetraploid <i>Brassica Campestris</i> var. <i>toria</i> in relation to fertility.

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

- | | | | |
|-----|-------------------|-----|--|
| 18. | S. P. Gupta | ... | Nitrogen fixation by azotobacter and associate organism. |
| 19. | J. R. Desai | ... | Effect of different doses of phosphates on the fixation of nitrogen by Rabi and Kharif legumes. |
| 20. | D. P. Motiramani | ... | Study on the wilting of gram with respect to the deficiency of micronutrient elements such as mx, cu, zn, I. |
| 21. | N. Patnaik | ... | Examination of profiles of saline soils at Karnal. |
| 22. | K. N. Syngal | ... | Examination of profiles of saline soils at Delhi. |
| 23. | P. Sinha | ... | The effect of continuous manuring and cropping on the nutrient level of Pusa soil. |
| 24. | D. V. Krishna Rao | ... | Studies on foliar diagnosis, leaf composition for N, P, K and Ca and their ratios in leaf in relation to yields and fertilizer treatments. |

ENTOMOLOGY

- | | | | |
|-----|---------------------|-----|--|
| 25. | Govindananda Sharma | ... | (i) Biology and Bionomics of the chalcid fly Proctotoma Sp. infesting capsules of sesamum and seshamia.
(ii) Review of literature on phytophagus chalcids. |
| 26. | J. P. Singh Teotia | ... | (i) Efficacy of Microbracon gelectriæ (Hym. Draconidæ) to control potato tuber moth gnorimoschema opercullela zell
(ii) Review of work done on the pests of potato and their control.
(iii) A comparative account of the last instar larvae of Apanteles and flavipes and Microbracon gelectriæ. |
| 27. | G. Ranga Ayyar | ... | (i) Biology and Bionomics of Nysius inconspicuous on tobacco.
(ii) Review of work done on tobacco pests. |

MYCOLOGY & PLANT PATHOLOGY

- | | | | |
|-----|--------------------|-----|--|
| 28. | B. D. Mundkur | ... | (i) Safflower rust.
(ii) Cytology of phytophthora sp. on potatoes. |
| 29. | K. S. Ali Khan | ... | Taphrina disease of corcuma spp. and rust of jowar. |
| 30. | R. P. Singh Nirwan | ... | Study of fungi in mixed cultures and effect of staling substances produced on the growth and parasitic activity. |
| 31. | T. K. Nariani | ... | Longivity of sugarcane red-rot fungus in Canes used for compost. |
| 32. | R. C. Patnaik | ... | Altarnaria on Brassica Spp. |
| 33. | J. Samraj | ... | Virus problem. |
| 34. | U. N. Verma | ... | (i) Lentil rust.
(ii) Microflora of stored grains. |

(b) *Students admitted during the year.*

AGRICULTURE

- | | | | |
|----|-----------------|-----|------------------|
| 1. | B. P. Tewari | 9. | R. A. Gupta |
| 2. | R. P. Agarwal | 10. | R. B. Singh |
| 3. | A. G. Prasad | 11. | C. P. Trivedi |
| 4. | K. C. Mohapatra | 12. | N. P. Sinnarkar |
| 5. | C. Patro | 13. | D. G. Dakshindas |
| 6. | M. D. Misra | 14. | K. S. Yawalkar |
| 7. | Sunder Singh | 15. | K. S. Shrotri |
| 8. | T. C. Sharma | 16. | N. S. Verma |

SUGARCANE AGRONOMY

17. K. C. Bhan Singh

18. R. C. Garg

PLANT BREEDING WITH SPECIAL REFERENCE TO SUGARCANE

19. R. C. Singh

BOTANY

20. B. L. Baruah

21. S. N. Singh

22. R. N. Prosad Sharma

23. G. Verma

24. M. S. Swaminathan

25. M. W. Hardas

26. R. C. Gorha

27. P. D. Bhargava

28. K. P. Pillay

29. A. P. Bahl

CHEMISTRY

30. P. B. Bhattacharjee

31. P. C. Ghosh

32. N. C. Padhee

33. V. S. Subrahmonian

34. Tinkari Das

35. P. C. Thakur

ENTOMOLOGY

36. A. C. Barbara

37. H. M. L. Srivastava

38. S. Krishnaswami

39. R. R. Rawat

40. C. U. S. Tomar

41. M. Lal.

MYCOLOGY

42. B. Gangopadhyay

43. T. K. Goswami

44. I. N. Tandon

45. S. B. Lal

46. K. V. Srinivasan

47. A. C. Jain

48. T. N. Kaul

49. K. B. Pisharodi

(c) Students admitted for short courses of training.

AGRICULTURAL ENGINEERING

1. P. D. Sharma.

2. U. Singh.

3. K. P. Mathur.

MYCOLOGY

4. B. D. Tiagi.

5. A. N. Parashar.

CHEMISTRY

6. Sant Singh.

(d) *Honorary Research Workers.*

BOTANY

1. G. Venkatratnam.
2. W. T. Butany.

MYCOLOGY

3. T. K. Nariani.
4. K. V. George.
5. Ramanath Menon.

ENTOMOLOGY

6. Bhambhani.



APPENDIX III.

List of papers published during 1947-48.

- Bose, B. B. A note on the biology of *Peecilonila Plagiola* Hmps. (Arctiidae). *Proc. 35th Indian Sci. Congr. Abstr. (Agric. Sec.)* 35: 16.
- Chinoy, J. J. Role of carbon assimilation in the production of dry matter. *Jr. Indian bot. Soc.* 24: 197-208.
- Chinoy, J. J. Correlation between the yield of wheat and temperature during ripening of grain. *Nature* 159: 442-444.
- Chinoy, J. J. & Nanda, K. K. Physiological studies in growth and development of crop plants. 1. Photoperiodic induction of developmental abnormalities in Indian wheat. *Indian J. agric. Sci.* 16: 390-399.
- Dastur, J. F. & Pal, B. P. Wheat rusts and their control. *Sci & Culture* 13: 91-98.
- Desai, S. V. & Subbiah, B. V. Some biochemical studies on nitrogen in soils and manures. *Proc. Indian Sci. Congr.*
- Dutt, N. L. Sugarcane improvement in India. *Indian Famg.* 7:
- Mukherji, S. On the probable role of soluble solids on the causation of resistance of susceptibility of the Indian species of *Sesamum* to the larval attack of *Antigastra catalaunalis* (Lepi: Pyralidae). *Nature* 160:
- Narayanan, E. S. Preliminary observations on the control of the Potato Tuber Moth, *Gnorimoschema operculella* Zell (Lepidoptera: Gelechiidae) by its natural parasite *Bracon* (Microbracon) gelechiae Ashm. *Proc. 35th Indian Sci. Congr. Abstr. (Agric. Sec.)* 35: 12-13.
- Parthasarathy, N. The probable origin of the North Indian sugarcane. *J. Indian Bot. Soc. (M. O. P. Iyengar Commemoration Volume)*: 133-150.
- Parthasarathy, N. The origin of noble sugarcanes (*Saccharum officinarum* L.) *Nature* 161: 608.
- Parthasarathy, N. & Rao, K. S. S. Chromosome survey of *Saccharum spontaneum* L. *Indian J. Genet. & Pl. Breed.* 6: 5-10.
- Prasada, R. *Darluka filum* (Biv.) Cast., a hyperparasite of *Puccinia graminis* and *P. triticea* in the green house. *Curr. Sci.* 17: 215-216.
- Pradhan, S. Rate of insect development under variable temperatures of the field. *Proc. Nat. Inst. Sci.* 11: 74-80.
- Pradhan, S. Idea of Biograph and Biometer (Instruments for estimating developmental periods and number of generations of insects in nature) *Proc. Nat. Inst. Sci.* 12: 301-314.
- Pradhan, S. Dynamics of temperature effect on insect development. *Proc. Nat. Inst. Sci.* 12: 385-404.
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